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# **The Role of Sociocultural Dimensions in Innovation Systems: the Gulf Cooperation Council**

**Lee Collins**

**Submitted in partial fulfilment of the  
requirements for the degree of  
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## **Abstract**

This research investigates the role of sociocultural dimensions in increasing national innovative capacity. While literature focuses on other determinants of innovation output, such as the stock of knowledge and resources dedicated to R&D, dimensions of a cultural nature have yet to be adequately addressed. The investigation examines sociocultural factors in natural resource-rich countries where the “urgency to survive” is not the primary driver in achieving economic growth. Oil-rich GCC countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, have made significant investment in education and information and communications technology to develop their economies. The primary focus in developing the economies has shifted to increasing innovative capacity. This study attempts to determine other factors that need to be in place to achieve increased innovative capacity as measured by new-to-the world knowledge and innovation. Endogenous growth theory and national innovation systems provide the theoretical base for the investigation. A deductive approach will be used to produce hypotheses that will be tested quantitatively, using existing indicators for sociocultural dimensions. Five sociocultural dimensions were found to be significant in innovative capacity when tested in leading innovator countries (Germany, Japan, Sweden, Switzerland, United States), emerging innovator countries (Denmark, Finland, Ireland, Korea), and GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates) as a whole. However, three of the dimensions, Openness to Outside Influences, and Adaptability were unexpectedly inversely proportional to innovative capacity. More precise measurements and further research are required.

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I declare that the work contained in this thesis has not been submitted for any other award and that it is my own work. I also confirm that this work acknowledges opinions, ideas and contributions from the work of others.

Lee Collins

July, 2013

# **Chapter 1 Introduction**

## 1.1 Background

## 1.1 Background

The search for sustainable economic growth has led economies to investigate frameworks and systems that act as a guide in using innovation as a means of growth. Recognizing that the modern technological paradigm allows the creation of new knowledge and its dissemination at a faster pace and to a wider network than ever before, governments, policy makers, and firms are seeking a better understanding of innovation processes.

Innovation first received scholarly attention as a separate field in the 1960's (Fagerberg, 2005), and the result of this attention was an expanded understanding of innovation's determinants and social and economic impact. One insight gained from the research was a realization that national choices made a difference in innovation. For example, Germany and Japan, leading innovators, accomplished huge jumps in national innovative productivity in the 1970s and 1980s, after the U.S. was no longer the driver of innovation that she had been during the two countries' reconstruction (Furman and Hayes, 2004). Secondly, it was noticed that a group of countries, considered imitators in 1979, were able to increase their innovation productivity in twenty years to a far greater extent than countries that had more favourable conditions at the start year. This new understanding led to the proposal of a systems approach to innovation to better manage an economy's innovative capabilities (Lundvall et al., 2002). Within the national systems approach researchers recognized that innovation had to be understood within its national institutional and cultural context (Lundvall, 2002; Lazonick, 2002).

This research investigates the national cultural context that enhances innovative capacity. "National innovative capacity is the ability of a country—as both a political and economic entity—to produce and commercialize a flow of new-to-the-world technologies over the long term" (Furman et al., 2002:2) The research focuses on Gulf Cooperation Council (GCC) countries, resource-rich economies that are cushioned against economic shock through their wealth in traditional factors of production such as oil and gas. Several of these countries are now facing dwindling oil and gas supplies, and because of globalization and social pressures due to unemployment and unequal wealth distribution, the countries have stated their intent to develop knowledge-based economies (UNDP, 2009). As they have progressed in building their knowledge-based economies,

considerable focus has been placed on innovation (UNDP, 2009; Al Ulama, 2007) and how to increase national innovative capacity.

## **1.2 Statement of the Research Problem, Motives, and Goals**

This research intends to broaden the scope of scholarship by determining the contribution of cultural factors, called sociocultural dimensions, to national innovative capacity. Culture incorporates the values, beliefs, and norms of behaviour and the resulting social interactions, which affect economic behaviour (Gorodnechenko and Roland, 2010). The study of cultural contributions to innovation is in its infancy stage and quantifying these contributions offers value, not only to developed countries, but more importantly to developing countries and emerging markets to determine a way forward in increasing innovative capacity. Examining GCC countries in conjunction with leading innovator countries and emerging innovator countries as defined by Furman and Hayes (2002) will permit a clearer picture to emerge about what sociocultural dimensions increase innovative capacity and how they may be developed through policy and investment. It is hoped that the research will extend or otherwise modify pre-existing thoughts on sociocultural contributions to innovative capacity and add to scholarship on the National Innovation Systems approach.

The ultimate goal of generating new theory from the data is to better inform practitioners engaged in creating and managing national innovation systems. It is intended to provide a link between innovation systems theory and the practice within firms, scientific labs, and universities engaged in the innovation process.

## **1.3 The Literature**

The literature review draws from a cross-discipline body of work that includes economic theory, innovations systems theory, sociology, business management, and anthropology, among other disciplines. The determinants of innovative capacity have not been adequately addressed in one body of literature. The theoretical base encompasses three strands of literature: development of technology/knowledge/innovation since the Industrial Revolution, economic growth theory, and innovation systems. The sociocultural environment discussion examines cultural characteristics that drive the transition to a knowledge-based economy and that develop creativity and innovation as discussed in business management, economic, and other academic literature.

Historically, three accelerations in new knowledge have occurred in the past two centuries: the first Industrial Revolution, the second (starting 1860) Industrial Revolution, and the latter decades of the twentieth century (Mokyr, 2002). This third era has been labelled a knowledge economy, or knowledge-based economy (Machlup, 1962; Drucker, 1968), and is the environment in which this research takes place. The most valuable outcome of the first Industrial Revolution was not that it involved the use of knowledge, but rather that learning and innovation became a universal process. Industrial Revolution II was a period of growing interaction between propositional knowledge: the epistemic base of knowledge (know what), and prescriptive knowledge: techniques or recipes (know how to) (Mokyr, 2002). The significance of the third revolution was that the body of useful knowledge had become vast, and the low cost of access made it widely available to everyone. While definitions of and perspectives on the knowledge-based economy vary (Becker, 1964), this research considers the knowledge-based economy to be one in which technological innovation, knowledge creation and dissemination, and human creativity are the primary determinants of economic growth (Chen and Dahlman, 2004).

At the same time as the modern technological paradigm was developing, economists were developing new thinking on economic growth. Solow (1956) introduced technological progress as an exogenous force in the production function, one outside economic interaction. Romer (1990) took this thinking a step further in defining an endogenous growth model that introduced technology as a determinant in the production function and showed how technology interacted with other factors of production to produce growth. Thus, changes in knowledge creation and dissemination and the resulting innovation were now reflected in endogenous growth models. This opened new ways of thinking about economic growth. Technology as Total Factor Productivity (TFP), a large part of which is attributable to technological change, explained much of the difference in level and rate of economic growth across countries (Abramovitz, 1993; Easterly and Levine, 2001; Hall and Jones, 1999; King and Levine, 1994).

The increased base of knowledge and new technological capabilities in Information and Communication Technology (ICT) made knowledge more widely available and expanded the opportunities for innovation, which now was recognized as a significant force in economic progress. Thus, a systems approach to innovation was proposed by scholars and policy makers (Edquist, 2005). Systems of innovation were primarily defined in terms of determinants influencing innovation processes, yet researchers used different approaches to its study and focused on different

determinants (Lundvall, 1992; Nelson, 1993). While Nelson focused more narrowly on national Research and Development (R&D) systems, Lundvall agreed with Freeman in recognizing that organizations that supported R&D were “embedded in a much wider socio-economic system in which political and cultural influences as well as economic policies help to determine scale, direction, and relative success (Freeman 2002: 195).” Generally, systems of innovation include “all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion, and use of innovations” (Edquist, 2005: 183). Culture, as one of these factors, plays a role in national innovation systems in imposing constraints on and determining actions of individual behaviour (North, 1990). Yet, culture is evolutionary in that it is dynamic and changes over time (Eric and Dumpy, 1998; Steward, 1955, [1979]). When the standards of behaviour no longer satisfy a society, culture evolves to meet the changing societal needs, and new behaviours and values become institutionalized (Eric and Dumpy, 1998). Culture contributes to innovation, and because it is not a static force, a culture not conducive to innovation can change over time.

One method of identifying sociocultural dimensions that contribute to innovative capacity is determining cultural characteristics needed to transition to a knowledge-based economy. Adaptability to changing circumstances, openness to outside influences in new ideas and technology acquisition, and openness in communication are examples of these characteristics (Castells and Cordosa, 2005; Drucker, 1964 [1986]). Also relevant to a discussion on sociocultural dimensions is literature on innovation and creativity (Negroponte, 2003; Lundvall et al., 2005; Page, 2008), which indicates that diversity in thinking (cognitive diversity), willingness to take risks, adaptability, and a lack of respect for authority are among cultural characteristics that contribute to creativity. Two other topics of literature, both widely discussed among economists and other social scientists, are also included in the Literature Review: social capital (Putman, 2000) and trust (Fukuyama, 1995).

## **1.4 Research Questions**

The research questions attempt to fill the gap in the literature by identifying the significance of sociocultural dimensions in innovative capacity. More specifically, they seek to determine the role of sociocultural dimensions in a national innovation system, with the intent to draw lessons for developing and emerging market countries that have the funds to invest in research and development. The research questions to be addressed include:

1. What sociocultural dimensions contribute to increasing national innovative capacity?
2. What is the significance of these factors in innovative capacity in GCC countries?

## **1.5 Research Method and Ethical Considerations**

According to Kuhn (1970) and others (Blaikie, 2000), research enquiries can be situated within a particular paradigm, and the paradigm determines the strategy and other aspects of the research. The paradigm used for this research is Critical Rationalism, which indicates a deductive approach (Blaikie, 2000). Sociocultural factors that underpin innovation in a knowledge-based economy can be deduced from characteristics that are revealed in transitioning to a knowledge-based economy, as well as characteristics associated with innovation and creativity in recognized innovative economies. The research constructs theory and expresses it as an argument and then tests the hypotheses by matching them with data. The research focuses on GCC countries that fit a category: resource-rich developing countries that are investing in a knowledge-based economy.

The widespread use of econometric models that measure economic output in relation to inputs (Furman et al., 2002; Furman and Hayes, 2004) indicates that a quantitative method can be used to demonstrate the significance of sociocultural dimensions to innovation output. Regression analysis offers the techniques that explore the relationship between a continuous dependent variable and a number of independent variables or predictors. It can also be used to address how well a set of variables is able to predict a particular outcome and whether a particular predictor variable is able to predict an outcome when the effects of other variables are controlled (Pallant, 2001:34). Therefore, an econometric model is proposed and existing data and indices will be used to determine the relationship between sociocultural dimensions and innovation output.

To answer the first question, the researcher used emerging and leading innovator countries during the 1979-1999 period as identified by Furman and Hayes (2004). The period is appropriate in that it directly precedes the era being studied for the GCC, 2000-2010. Using the three groups, emerging innovators, leading innovators and GCC, provides adequate iterations to test the number of sociocultural dimensions identified. To answer the second question, only the six GCC countries are used.

Ethics is considered critical to social research to ensure that those connected to the research are not adversely affected. In this study, secondary data is used from the most reputable resources

available. Given the scarcity of data on the GCC, attempts have been made to carefully evaluate sources before determining the most accurate and appropriate to represent the value required. The researcher has attempted to follow others in the field in their choice of sources, thereby creating a double check on data sources.

## **1.6 Impact on Practice**

The impact on practice is three fold. First, culture is evolutionary, and therefore sociocultural dimensions associated with innovation can be developed through training and experience (Page, 2008; Akerlof and Kranton, 2002) as a culture evolves. This will affect the responsibility and overall structure of the national education system and firm-level training departments in countries wishing to increase innovative capacity.

Second, developing countries that wish to increase innovative capacity can better focus on the criteria that increase innovation when creating policy and making investment in education and research and development.

Third, in traditional societies access to knowledge and information associated with increasing innovative capacity changes the power base of professional workers. Authority, based on access to information or ownership of information, is no longer viable. To enhance innovative capacity, professional practice will have to shift from power based on information not shared to one based on competence.

## **1.7 Content**

The thesis is designed to guide the reader through the development of technology and new knowledge and their relationship to economic growth to modern economic growth theory thinking and the development of innovation as a system. These topics are covered in Chapter 2. The discussion then examines sociocultural dimensions that are relevant to the development of a modern knowledge-based economy and to the encouraging creativity within a culture. Whereas Chapter 2 draws primarily from economic literature, Chapter 3 examines works by sociologists, psychologists, political scientists, technologists, and scientists. Chapter 4 on the Gulf Cooperation Council countries describes their common heritage, discusses their development paths in recent times, and examines their innovation systems.



Given this background of economic theory, identification of sociocultural dimensions that support the development of a knowledge-based economy and creativity, and examination of GCC countries, Chapter 5 defines a research method and model that will be used to determine the significance of sociocultural dimensions in their contribution to innovative capacity. This chapter also determines data sources that accurately reflect sociocultural dimensions. The findings and analysis of the results of the regressions run on the data appear in Chapter 6. In this chapter, the hypotheses are discussed and unexpected findings in relationships are interpreted. The final chapter, Chapter 7, concludes the research. This chapter identifies limitations faced in completing the research, offers implications for theory and policy, and suggests area for further research.

# **Chapter 2 Theoretical Review: Economic Growth and Innovation Systems**

## 2.1 Introduction

While there is agreement among economists and policy makers that technological innovation is a fundamental factor in economic growth (Abramovitz, 1956; Bush, 1945; Jones, 1995; Romer, 1990; Schumpeter, 194; Solow, 1956), the underlying drivers of innovation within a national economy are still being investigated (Furman et al., 2002). Investment in R&D is one such driver (Romer, 1990; Schumpeter, 1950) and illuminating other determinants has become a primary objective of economists and policy makers at the national level (Lundvall et al., 2002).

This research examines sociocultural factors as drivers of innovation within a modern knowledge-based economy. Lundvall (1992) alluded to the role of the socio-economic system in innovation when he stated that political and cultural activities helped to determine the scale, direction, and success in innovative activities. Economic growth literature has also indicated that sociocultural factors and economic behaviour are linked (Bangwayo-Skeete et al., 2009; Marx, 1976; McClelland, 1961; Weber, 1902 [2001]). However, there is a paucity of data and frameworks that focus on the exact nature of national cultural dimensions that increase innovative capacity.

The investigation targets Gulf Cooperation Council (GCC) countries, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. These countries are cushioned against economic shock through natural resource wealth, and the *urgency to survive* has not been the primary driver in achieving economic growth. Several of these countries are now facing dwindling oil and gas supplies, and because of globalization and social pressures due to unemployment and inequity in wealth distribution, the countries have stated their intents to develop knowledge-based economies (UNDP, 2009), of which an innovation system is a pillar (Chen and Dahlman, 2004). While GCC countries have made considerable investments in information and communication technology, in education, and in developing a supportive economic regime, the outcome has not resulted in an increased innovative capacity to fuel growth and development (UNDP, 2009). The quest, then, is to determine the significance of sociocultural dimensions in developing innovation, and the role these dimensions may play in GCC countries as they increase their innovative capacity. This will be accomplished by determining sociocultural dimensions' affect on innovative capacity in three groups of countries: (1) leading innovators, (2) emerging innovators (Furman and Hayes, 2004), and (3) the GCC. Leading Innovators and emerging innovators were identified during the 1979-1999 period, directly preceding the decade under investigation in this research. By

examining sociocultural dimensions in these two groups, the research can determine sociocultural dimensions that contribute to national innovative capacity in national economies identified as innovative.

The literature review draws from a cross-discipline body of work. Section 1, The Theoretical Base, draws from three strands of literature: development of technology/knowledge/innovation since the Industrial Revolution, economic growth theory, and innovation systems. The section begins with a historical perspective on the development of new knowledge and technology and its relationship to economic growth, starting with the first Industrial Revolution. This is followed by a discussion of the knowledge-based economy as a third revolution in the development of knowledge and innovation. Then, economic growth theory introduces neoclassical growth theory, the concept of knowledge as an infinite factor of production, and evolutionary theory that underpins innovation systems thinking. This is followed by a discussion of innovation systems, its components and links, and strategies for measuring inputs and outputs. A conclusion summarizes the different strands of the theoretical base for the current state of the knowledge/technology/innovation paradigm.

The second section of the literature review, Sociocultural Dimensions, primarily draws on works by sociologists, psychologists, political scientists, and academics who write on business-related topics. The section begins by explaining the concept of sociocultural dimensions and then determines sociocultural dimensions that will be tested. The dimensions are determined through an examination of economies as they transition to a modern knowledge-based economy, the environment in which innovation systems is being studied. The discussion is an attempt to answer the question of what is required of a society in such a transition. A second source of sociocultural dimensions is provided by diverse literature on innovation to answer the question of what in a society contributes to innovation. The third source of sociocultural dimensions is offered by a case study on Finland, a country that developed a National Innovation System and attributed part of its success in innovative outcome to sociocultural dimensions (Dahlman et al., 2006).

## **2.2 Knowledge – The Basics**

Kuznets (1965) argued that modern economic growth was based on the growth of the stock of useful or tested knowledge. His concept of *tested knowledge* meant scientific knowledge, and Mokyr (2002) added to this that useful knowledge could also include natural phenomena and regularities. Given the significance of new knowledge in economic growth, a brief understanding of

its nature and the types of knowledge considered as part of the knowledge stock is required.

### **2.2.1 The Nature of Knowledge**

Knowledge is different from an ordinary commodity in that it is renewable, or infinite, and builds on itself, whereas traditional factors of production are finite and face scarcity. Knowledge is a public good in that once it has been discovered and made public, the cost of adding new users is virtually zero (Stiglitz, 1999), and yet knowledge provides benefit to everyone. Its availability is in no way diminished by its simultaneous use by others (Todaro and Smith, 2009). Therefore, the process of discovery in learning new things does not face a law of diminishing returns. As we learn, we get increasingly better at discovering new things, and there is no limit to the amount of things we can discover (Kurtzman, 1997). In the modern economy, knowledge is considered a factor of production in the economic sense, and its role in the production function will be discussed further in 2.5 Economic Theory below.

### **2.2.2 The Types of Knowledge**

According to Polanyi (1967), there are two types of knowledge: tacit and explicit. Explicit knowledge is know-what, what is normally conveyed in processes, formal documents, and educational institutions. Tacit knowledge is know-how, non-codified components of activity, and often consists of habits and culture that we do not recognize in ourselves. Tacit knowledge involves learning and skill but not in a way that can be written down, which makes codification difficult. Tacit knowledge comprises a range of conceptual and sensory information and images that can be brought to bear in an attempt to make sense of something (Hodgkin, 1991). Tacit knowledge can be understood to be knowledge that is embedded in a culture, a regional culture, organizational culture or social culture; and that knowledge is difficult to share with people not embedded in that culture (Davidsson and Honig, 2003). In their seminal work, *The Knowledge Creating Company*, Nonaka and Takeuchi (1995) discussed the concept of tacit knowledge in corporate innovation. The two researchers elaborate on the example of the first Japanese bread maker, whose development was impossible until the engineers interned themselves to one of Japan's leading bakers. During their internship, they were able to learn the tacit movements required to knead dough, and then transfer this knowledge back to the company.

Lundvall and Ernst (1996) offered a more detailed taxonomy of knowledge. They described four types of useful knowledge as follows:

- *Know-what* - knowledge about facts

- *Know-why* - knowledge about principles and laws of motion, knowledge useful in technology-based areas
- *Know-how* - skills or capability to do something
- *Know-who* - information about who knows what and requires a social capability

Know-what and know-why are akin to explicit knowledge in that they can be codified and disseminated. Both can be obtained through reading books, attending lectures and accessing databases and can be sold in the market. This explains why mainstream economic analysis focuses on learning processes that involve the transfer of know-what and know-why, while neglecting know-how and know-who (Lundvall and Ernst, 1996).

Know-how, or tacit knowledge, cannot be easily transmitted but is gained through learning-by-doing and through interacting with other experts in the same field (Howells, 1996). Chess, where players are faced with an immense number of possible combinations, involves mental exercise where the complexity of the task calls upon tacit knowledge (Lundvall and Ernst, 1996). Know-how is typically knowledge developed within the individual and resides within the individual and the boundaries of a firm or a research team. However, as the complexity of the knowledge-base increases, co-operation among organizations becomes more necessary. This explains formation of industrial networks which allow firms to share and combine elements of know-how (Lundvall and Ernst, 1996).

Know-who is rooted in social interaction, and this explains why university alumnae reunions and professional organization meetings and conferences take place. They allow communication and collaboration with colleagues from the same as well as diverse disciplines and industries (Lundvall and Ernst, 1998). Know-who may be considered social capital, which has been defined as social networks and the norms of reciprocity associated with them (Putnam, 2002). Know-who can be a basis for power in traditional societies where knowledge is power and not shared with those outside an inner circle (UNESCO, 2005).

A third taxonomy on knowledge was offered by Mokyr (2002), who divided knowledge into propositional knowledge: the science, beliefs or the epistemic base of knowledge (know-what), and perscriptive knowledge: techniques or recipes (know-how). An addition to propositional knowledge would be a discovery, and an addition to perscriptive knowledge would be an invention. Mokyr claimed that both of his knowledge types reinforced each other and that the Industrial Revolution

was a period of unprecedented growth in such knowledge. Although discoveries (propositional knowledge) seemed more valuable, techniques and practical applications of knowledge (perspective knowledge) could provide a multiplier effect in that knowledge could be transmitted to other applications. Mokyr saw propositional knowledge as more critical because it was the epistemic base of knowledge. He noted that the epistemic base promoted productivity and more efficient discovery mechanisms. There is a minimal epistemic knowledge required, without which techniques cannot be conceived. A narrow epistemic base of technological knowledge means that people can figure out what works but may not understand how or why things work. For example, improvements, adaptations to changing circumstances, and new applications and extensions are more difficult with a narrow epistemic base.

### **2.2.3 Summary**

Knowledge is a public good, and its availability is not diminished by its simultaneous use by others (Todaro and Smith, 2009). Because knowledge builds on itself, invention builds on the store of existing knowledge to create a new idea or process. Determining taxonomies of the types of knowledge is not as important as understanding the relationship between the different types of knowledge. The store of knowledge within an economy includes the knowledge of facts, processes, and explanations, which are easily codified and disseminated; the knowledge of networks to which one might gain access and which involves social capability; and the knowledge of knowing how to intuitively proceed, which is experience-based and difficult to access. Codified knowledge facilitates the use of knowledge associated with the knowledge-based economy because through ICT capabilities it can potentially be made available to everyone. The second, know-who, assumes that a knowledge source is known, and the knowledge source is willing to share the knowledge. This is a critical aspect in traditional societies in that knowledge is power and not willingly shared except in closed networks. There is pressure to codify the third, know-how. However, it is much like asking a Ferran Adria, the world-renowned chef at three-Michelin-star El Bulli restaurant (now closed) to share his recipes with the expectation that one could then prepare the same meal. Rather, experienced and expert chefs request a six-month apprenticeship at the restaurant to be able to emulate his expertise (Abend, 2012).

An essential point for any knowledge-based economy is that all types of knowledge are needed. A society's ability to innovate depends on its level of tacit knowledge of how to innovate (Collins, 2001) and solving complex problems and making entrepreneurial decisions requires both tacit and explicit knowledge (Davidsson and Honig, 2003). Polanyi (1967) suggested that scientific inquiry

could not be reduced to facts, and that the search for new and novel research problems required tacit knowledge about how to approach an unknown. Experienced-based knowledge (tacit knowledge) can be even more crucial in a knowledge-based economy because requirements for skills are constantly changing (Lundvall and Ernst, 1996). A discussion of the technology and characteristics of knowledge that provided the impetus for the first and second industrial revolutions and the knowledge-based economy follows.

## **2.3 Historical Setting**

Technological progress, starting with the first Industrial Revolution (1760), can be described as a trajectory that started with a major or macro invention, which was continuously refined and improved through incremental innovations until the knowledge base was exhausted (Mokyr, 2002). A static state would set in until the next macro invention emerged. According to Mokyr, there have been three accelerations in innovations that have occurred in the past two centuries: the first Industrial Revolution, the second (starting 1860) Industrial Revolution, and the latter decades of the twentieth century. This third era has been labeled a knowledge economy, or a knowledge-based economy (Machlup, 1962; Drucker, 1968), and is the environment in which this research takes place.

### ***2.3.1 Industrial Revolution I***

While technology made limited contributions to economic growth pre-1750, it became the driving force in the first industrial revolution and led to unprecedented growth in knowledge and innovation. Technology can be thought of as the creation or use of tools or techniques to solve a problem or improve on an existing solution. Mokyr (2002) argued that the differences in innovation of the scientific revolution of the 1760 and 1770s and the previous era lay in the expansion and deepening of the epistemic base of techniques and the set of propositional knowledge, thus enabling more sustainable technological progress. It was also due to improved access to propositional knowledge by engineers and entrepreneurs. The period was accompanied by changing social values in cooperation and in the sharing of knowledge made possible through printing and writing (Mokyr, 2002).

There are alternative perspectives for why the Industrial Revolution and the transition to innovation-based growth happened in Northwestern Europe and not in China, Japan, and India. Pomeranz (2000) suggested that crucial factors for the transition included the acquisition of



colonies, as markets for manufactured goods and sources of food and raw materials, and the development of a new energy source, coal. Other explanations focused on institutional changes such as property rights for innovations (Braudel, 1984; Landes, 1998; Wallerstein, 1974). Jones (1988) argued that political institutions based on surplus extraction inhibited innovation, and that the weakened 17th century political power in Northwest Europe provided the opportunity for innovation-based growth.

Whether emphasizing technological breakthroughs or technological, organizational, and institutional change as the cause of growth in the Industrial Revolution, scholars agree that technological innovation was a major driver in growth. Evidence of this innovation can be found in the increase in patents at the time and in sectoral innovations (Bruland and Mowery, 2005). The textile industry and the steam engine, the emblems of Industrial Revolution I, were not the only industries that benefited from the increase in innovation. Key innovations were also developed in agricultural equipment and food processing, distribution, and consumption (Bruland and Mowery, 2005).

Two aspects of innovation in the Industrial Revolution I are worth mentioning. First, innovation was generally the result of individual inventors, regardless of their affiliation with a workshop or enterprise. Second, the increase in innovation did not depend on science, as it is currently defined. The changes came more from trial and error than research and development (Mokyr, 2002). As suggested by some, knowledge may have started as tacit but became more codified and therefore diffused as the revolution progressed.

Two characteristics of a change in institutions are relevant to the innovation systems concept that developed later. Business organizations, because of legal changes, were able to gain limited liability or separate identity status and outside financing, both of which enabled growth. A separate characteristic involved a change in labour structure and management requirements to a more structured, rules-based working day with an integrated workforce and a strengthened managerial power (Bruland and Mowery, 2005).

### ***2.3.2 Industrial Revolution II***

The second phase of the industrial revolution involved a shift away from the British model of basic industries, which had diffused to Europe and the United States, to new industrial sectors. The scientific discovery that acted as impetus for this second phase was Faraday's demonstration of

electromagnetic induction (1831), which opened the possibility of generating electricity by mechanical means (Bruland and Mowery, 2005). Engineers worked for decades with the technical issues of generating electricity in quantities and at prices that would make commercialization feasible before Faraday's discovery resulted in the technological innovation in electrical equipment and electric power generation that defined industries in the second Industrial Revolution (Mokyr, 2002). According to Mokyr, this was another example of the complex relationship between propositional and perscriptive knowledge. Faraday's discovery had a narrow epistemic base, but it could not be commercialized until the technical problems had been worked out (perscriptive knowledge). Other scientific inventions, the first synthetic dyestuff for example, required complex process technology before they could be exploited, while other industries did not require new scientific knowledge for technological innovation (Bruland and Mowery, 2005).

Industrial Revolution II was characterized by organizational innovation in the increased reliance on organized experimentation rather than the serendipity of individual invention (Murman and Landau, 1998). The stronger connection between industry and science resulted in emphasis on formal training for potential inventors, in institutions outside the firm conducting formal research, and in the codification and sharing of scientific and technological knowledge as a driver of a firm's core competency (Bruland and Mowery, 2005). This led to a change in firm structure through incorporation of in-house research and development departments and working with scientific contacts in education.

Most of the productivity increase in the twentieth century was the result of the perfection of production techniques and process innovation. These included routinization, which made production processes interchangeable. Another component was modularization by making identical parts interchangeable and by the specialization of labour. The familiarity of the worker with a process allowed him to introduce improvements and get better at the process (Babbage, 1835 [1989]). An optimal matching of tasks to ability was possible (Rosenberg, 1963). On a knowledge basis, this meant that a worker needed to know only his or her part of the process and could become an expert on that part.

Drucker (1968) saw the aftermath of the Industrial Revolution I as the beginning of economic trends, which continued unabated until the 1960s. With the possible exception of Russia, old industrial regions grew to industrial states with basically the same economic structures and the same industries' proportional contribution to GDP. Although new industries, such as airlines and

computers, emerged, in terms of “contribution to GNP, personal income, and employment” (Drucker, 1968: 6), only plastics attained major economic importance. Although there was significant change in politics, science, world-view, the arts, and warfare, the economist of 1913 could have forecast the industry structure of the 1960s (Drucker, 1968).

From around the time of World War I through World War II was a period of political and social upheaval and economic growth, the latter due to technology resulting in a continuous flow of micro inventions in several sectors. From a knowledge perspective, the continual technological progress was made possible because of the widening of the epistemic base of techniques already in existence in 1914. However, there were almost no macro inventions, with the exception of nuclear power, which faced challenges in cost, disposal of waste, and affects on health and did not reach its potential in fundamentally changing society (Mokyr, 2002).

Just as previously occurred, a macro invention was developed that led to an increase in innovation and a revolution or radical change from the previous era. In the case of the knowledge-based economy, the major macro inventions were the microprocessor and the discovery of DNA, both of which added to the knowledge base and provided a means of technological change. DNA changed the methods of R&D by providing the use of new knowledge, DNA, to improve the manufacture of substances whose way of operating was already understood. It also permitted the use of advanced genetics in the discovery of new drugs (Mokyr, 2002b). The semiconductor offered the ability to recombine with other techniques and was complementary to downstream innovations (Helpman and Trjtenberg, 1998). This created a profound change in the generation and deployment of knowledge, as we shall learn in the discussion of the knowledge-based economy.

### **2.3.3 Summary**

The most valuable outcome of the first Industrial Revolution was not that it involved the use of knowledge, but rather that it routinized learning. While inventions and innovations did develop and diffuse prior to industrialization, the process was marginal, slow, and uneven. During the period of industrialization, learning and innovation became a universal process. Technical change became the driving force in defining jobs for engineers and workers, and demand for skills in management increased. Technical change had different effects on the engineers and workers in that it increased the demand for skill-intensive mechanical engineering but narrowed the skills required from workers using machinery (Lundvall and Johnson, 1994)

The most successful economies in Industrial Revolution II were those in which connections were the most efficient in sharing the knowledge base. Institutions created these links, and these institutions included universities, research departments and institutes, and other research facilities. Improved access to useful knowledge was a characteristic of successful firms and economies. Mokyr (2002b) saw Industrial Revolution II as a period of growing interaction between propositional and perscriptive knowledge. Improved instruments and laboratory equipment (techniques) helped scientists to learn about natural phenomena, which may be un-seeable by human evolution, thus widening the epistemic base.

Another outcome of the industrial revolutions was the realization that a creative community was a driving force in using technology to cause innovation. Previously, historians of technology had felt that individual inventors were the main actors behind the Industrial Revolution. While this was perhaps true in Industrial Revolution I, the crucial force was a few thousand people who formed a creative community based on the exchange of knowledge. Engineers, mechanics, chemists, physicians, and philosophers formed groups in which access to knowledge was the primary objective. Their appreciation that knowledge could be the base for expanding prosperity made networks indispensable to them (Mokyr, 2002).

The significance of the information age to come was that the body of useful knowledge had become vast, and the low cost of access made it widely available to everyone. While tacit knowledge could not be readily acquired in such a way, it would be easier to find who had the tacit knowledge and therefore gain access to the expertise. This made growing access to a common knowledge a catalyst in the technological progress of the next revolution, the knowledge-based economy.

## **2.4 The Third Revolution – Knowledge/ICT/Innovation**

Just as Faraday's discovery of the dynamo in 1831 did not result in the innovation of generators for electricity until 1870s, so innovations resulting from the microprocessor and DNA did not cause an immediate disruption until later in the twentieth century. Understanding this third revolution, the knowledge-based economy, is relevant in two ways: first it provides the environment in which this study takes place. Economies that are not yet considered knowledge-based are moving toward becoming such an economy as an ideal. Second, examining the characteristics of a cultural nature that aid the transition to a knowledge-based economy will be considered in determining the list of sociocultural dimensions to be tested in their contribution to innovative capacity.

Drucker (1968) believed that the world faced an Age of Discontinuity, starting with the 1960s. He saw the discontinuity as occurring in four areas:

- In emergence of technology  
The development of new technologies resulted in a shift in production in existing industries and a shift to new industries based on the new technologies. Whereas mature industries traditionally demanded more manual workers, the new technologies offered new opportunities and demanded knowledge workers and a different logic and perception.
- In emergence of a global economy  
The world economy would become the “policy-setting centre for all economies and the area in which new economic and social institutions would evolve (xiii).”
- In emergence of a new pluralism in institutions  
Drucker forecast institutional diversity and diffusion of power as a characteristic of the closing decades of the twentieth century. No one large institution, like the central government, would dominate. “The pluralistic structure of modern society is independent...of political constitution and control, of social theory, or of economics.” (185). An organization would have to satisfy its objective or mission and at the same time satisfy needs of organization members in order to gain their service. Performance, then, would become the foundation for authority and what justified an organization’s existence.
- In emergence of knowledge as the central resource of an economy  
The most important step toward the knowledge-based economy was Taylor’s (1911) application of analysis to manual work in the last decades of the nineteenth century. He saw that the key to productivity was knowledge to work smarter, rather than work more or work harder. In applying scientific management to work that had never been skilled, he was the precursor of managers of institutions becoming the new power centre. This set the stage for responsibility and accountability of knowledge and men and women of knowledge becoming a central issue for political theory, public policy, and moral concern (Drucker, 1968: Preface to 1986 addition).

#### **2.4.1 The New Economy Definition**

The new economy has been referred to by diverse terminology and defined in subtly different ways, depending on the agenda of the author or organization that the author represents. Following is a brief discussion of how the knowledge-based economy has been defined in economic development, sociology, and economic literature. The purpose is to clarify how the term will be used in this research

Fritz Machlup is considered to be the initiator of the knowledge-economy concept (Godin, 2008). Machlup's study on knowledge in the U.S defined knowledge, offered a method to measure it, and discussed policy issues primarily concerning education and research. His definition included scientific and ordinary knowledge as per Ryle (1949) and later Polanyi (1958). He added that knowledge was both its production and its distribution: information is knowledge only if it is communicated. As measurement he used national accounting to identify inputs and outputs of knowledge within an economy, rather than the function of knowledge within the economic system (Machlup, 1962).

Drucker (1968) built on Machlup's concept in stating that America had changed from an economy of goods to a knowledge-based economy. He based this on the fact that "knowledge industries" (as described by Machlup, 1962), which produce and distribute ideas and information rather than goods and services, were a much larger proportion of GNP in 1965 than in 1955, and the proportion was still growing. Drucker stated that knowledge became the primary industry because it supplied the essential resource of production, whether in manufacturing or in services, which usually depended on manufacturing in some way. Economists classified "knowledge industries" as "services" to differentiate them from primary industries, such as oil production, and secondary industries, such as manufacturing (Castells, 2005).

Castells (2005) conceptualized the transformation to the new paradigm differently to Drucker. He agreed that a structural transformation was taking place, and that it was founded on a new technological paradigm of information and communication technologies that took shape in the 1970s. The new technological system was rooted in microelectronics, computing, and digital communication, their growing connection to biological sciences, and their capabilities in digital communication networks. He took exception to the label, knowledge economy, "not because knowledge and information are not central in our society, but because they have always been so, in all historically known societies" (4). He used the term, the network society as the social structure resulting from the interaction between the new technological paradigm and social organization at large.

While Castells and Drucker offered a social and business perspective respectively, Romer (1990) spoke from an economist's perspective about knowledge as a factor of production. He claimed that, "My work on growth can be traced back to an attempt to isolate the differences between the

information or knowledge-based economy and what came before it. My belief is that those differences are important for our understanding of growth” (Kurtzman 1997: 1). A key point in his perspective was that knowledge was unbound or infinite, where as other factors of production were finite.

Other economists writing on economic development looked at the term from social and economic perspectives. Lundvall and Johnson (1994) explained the learning economy was one in which “the capability to learn determines the economic success, not only of firms and industries, but also of whole regions (industrial districts) and countries.” (7). The concept of the learning economy was based on the following propositions: learning was an interactive, socially embedded process and its efficiency depended on the formal institutions set-up and the national innovation system. Because knowledge was the most fundamental resource in the economy, learning was the most important process, and learning was a socially embedded process, which took into account its institutional and cultural context (Lundvall et al., 1992).

International organizations, such as the OECD (1996) described the knowledge-based economy as encompassing the following:

- Investment in knowledge: research and development, education and training, and new managerial work structures are key.
- Knowledge distribution: tacit and codified knowledge and transmission through communication networks, flows and relationships among industry, government, and academia in the development of science and technology, through collaborative networks.
- Innovation: driven by interactions of producers and users in the exchange of knowledge rather than a traditional linear model of innovation.
- Skilled workers: Increasing demand for more highly skilled workers.
- Government policy: stressing upgrade in human capital by promoting access to a range of skills and developing the capacity to learn.
- Collaboration among the science system, research laboratories, and institutions of higher education and industry.

In the early twenty-first century, Chen and Dahlman (2004) discussed the knowledge-based economy for the World Bank. They defined it as an economy in which technological innovation, knowledge creation and dissemination, and human creativity were determinants of economic growth. They used this definition as a base for their Knowledge Assessment Methodology (KAM)

framework for the World Bank, a template that can be used to measure a nation's readiness for the knowledge-based economy. It has been suggested that building a knowledge-based economy can be used as a strategy for economic development and that this rating is perhaps a guide to progress in using this strategy (Aubert and Reiffers, 2003). The template includes four pillars:

- (1) An economic and institutional regime that encourages efficient creation, dissemination, and use of knowledge to promote growth and increase welfare.
- (2) An educated, creative and skilled population that can create and use knowledge.
- (3) A well-developed information and communication infrastructure that can facilitate effective communication, dissemination, and processing of information.
- (4) An effective innovation system, with dynamic interaction between the world and science, technology, and business that can tap into global knowledge, adapt it to local needs, and transform it into products valued in the market. (Aubert and Reiffers, 2004: 11)

A fifth pillar addresses “the intangible factors that make a society function efficiently and move forward, such as the capacity to formulate a vision, the level of trust and self-confidence, and the appropriateness of guiding values...these qualitative elements are the driving force in the move toward new models of development” (Aubert and Reiffers, 2004: 11).

Terms used in this section include “knowledge-based economy”, “knowledge economy”, “information economy”, “learning economy”, “information society”, “knowledge society” and “network society”. Romer used the terms “information economy” and “knowledge-based economy” interchangeably while Drucker discussed the “knowledge-based economy” in an economic sense and used “knowledge society” when discussing changes in society as a whole.

Given the variation in terminology and subtle diversity in definition, this investigation follows an economic growth perspective rather than a broader social and economic development perspective. Economic theory underpins thinking on innovation systems and on the econometric model that will be used to determine the significance of sociocultural dimensions within national boundaries. Therefore, “knowledge-based economy” will be used to indicate an economy in which technological innovation, knowledge creation and dissemination, and human creativity are the primary determinants of economic growth rather than traditional factors of production. The fundamental change that occurred was due to technology in its capability to more quickly create and disseminate knowledge, in its use in innovative processes, and in its networking capabilities in connecting societies, markets, suppliers, and production. The following sections discuss characteristics of infrastructure that support these fundamental changes.



## 2.4.2 Knowledge-based Economy Infrastructure

Studies on the effect of infrastructure, both institutions and physical entities, on macroeconomic productivity and economic growth are numerous (, Aschauer, 1989; Barro, 1997; Devarajan et al., 1996; Easterly and Rebelo, 1993; Ratner, 1983), and there is consensus that an institutional framework supports economic development (Kaufmann et al., 2002; Knack and Keefer, 1995; North, 1990; Rodrik et al., 2002). Referring to these works will provide the reader greater insight into the general framework conducive to economic development. What is relevant for this investigation is to determine what may be unique in an infrastructure that supports a knowledge-based economy conducive to innovation.

### Leadership

Leadership creates an economic and institutional regime “such that economic agents have incentives for the efficient use and creation of knowledge.” (Chen and Dahlman, 2005:8). Rischard, in Table 2.1, differentiates the government mindset for a knowledge-based economy from previous ideologies and places emphasis on building opportunities and providing a vision for society.

**Table 2.1**

<i>Mindsets</i>	<i>Liberalization</i>	<i>Modernization</i>	<i>Knowledge Economy</i>
Is about	Undoing things	Building things	Building winning opportunities
Creates	Freedom Fluidity Even playing field	Modern institutions Rule of law Good basic business	Vision A vibrant home base for business A winning mentality Clusters
Main focus	Stability incentives	Productivity catchup	Becoming globally competitive
Domain	Economy	Economic	Societal
Role of government	Get out of the way Stop being an operator	Become an integrator	Become a challenger Become a good regulator

*Source:* Rischard, 2002.

Government is an institution in the National Innovation Systems (NIS) paradigm and will be discussed further under 2.7 National Innovation Systems. Government policy and regulations in knowledge-based economy should emphasize the following:

- A competitive business framework that creates incentives that encourage and reward innovation
- A financial sector that helps develop the non-bank financial sector, which plays a central role in

financing innovative businesses

- Policies that support trade and investment to encourage business innovation through external competitive pressures
- Labour market flexibility to facilitate mobility and the employment of skilled personnel in the most dynamic firms (World Bank, 2008b).

### **Technology and Information and Communications Technology (ICT)**

A knowledge-based economy requires a developed telecommunications and information technology infrastructure to function. Unless widespread access to ICT is available, the use of new knowledge will be limited to a few major or foreign-owned enclaves (World Bank, 2008b). At the national level technological progress, and the subsequent development of ICT, may occur in several ways: through innovation and invention, through exposure to pre-existing technologies and through the spread of technologies across sectors to firms, individuals, and government entities (Keller, 2004). Developing countries are dependent on adoption and adaptation of pre-existing technologies. This may occur through trade, through FDI, and through contacts with other communication channels, such as students sent abroad for education, academia, diaspora, and membership in professional organizations that expose members and attendees of conferences to the latest processes and thinking within their specific field (Brinkerhoff, 2005a, 2006b; Kapur, 2001).

It has been suggested that exporting firms benefit from technology transfers that result from interaction with foreign buyers, who may have higher standards and assist with process improvements and foreign market expertise (Hobday, 1995, Rhee et al., 1984). Econometric studies do not necessarily confirm this benefit (Keller, 2004). Rather the success of the import/export strategy depends on the absorptive capacity of a country. Countries with weak scientific capacity and technical capabilities are more likely to import high tech goods or open local assembly plants from which technology goods are exported (Soubbotina, 2006). This does not necessarily benefit their store of technological know-how.

A developing country's ability to absorb technology, once exposed, depends on a willingness to adopt, the macroeconomic environment, government policy, and the level of skills within the population. The extent to which technology is used depends on education of the population (Caselli and Coleman, 2001; Eaton and Kortum, 1996), the quality of the labour force, and an ability to pay and get financing and access (World Bank, 2008b). Without the diffusion throughout the nation, technology cannot reach its maximum potential in developing a knowledge-based economy, and the

nation may not develop the resilience to meet modern change.

## **Education**

In a knowledge-based economy, the value of human capital lies in continual renewal of knowledge to keep pace with rapid changes in technology. This may require an expansion in educational objectives from emphasis on the traditional rote education of learning basic skills and literacy to learning critical thinking, training in accordance with labour market demands, and an emphasis on life-long learning (Aubert and Reiffers, 2003). The critical thinking required for knowledge transfer can be developed through the structure of the learning process. Education can also be used as a catalyst to shape cultural values (Bangwayo-Skeet et al., 2009). Schools provide an image of the ideal student in terms of characteristics and behaviour and can therefore create learning environments that promote ideals associated with economically useful cultural norms and skills required in a knowledge-based economy (Akerlof and Kranton, 2002).

As previously stated, both codified knowledge, know-what and -why, and the competencies to interpret and use the information, know-how, are mandatory in a knowledge-based economy. The fundamental difference in a knowledge-base economy is the available amount of knowledge due to the rapid pace of knowledge development and dissemination. The emphasis for education professionals therefore must be on actively keeping up with the latest developments in their respective fields.

Literature suggests that university-industry links can provide a base for entrepreneurship (Laursen and Slater, 2004). The role of universities in this context will be discussed further in 2.7 National Innovation Systems.

## **Innovation System**

A knowledge-based economy requires an innovation system that encourages and guides output that is commercially viable. While invention was originally an individual-based activity, as the epistemic base of knowledge became broader, the techniques more numerous, and dissemination wider due to ICT, invention and the resulting innovation became more group dependent (Mokyr, 2002). A systems perspective on innovation has been the result. The objective of an innovation system is to create an environment in which new ways of thinking can happen and be brought to fruition through supportive policies on the part of governments and firms (Edquist, 2005). The section on Innovation Systems (2.6) investigates innovation systems literature against the backdrop of the knowledge-based economy in which it functions.

### **2.4.3 Summary**

While the end of the knowledge-based economy era has not been declared, benefits can be recognized in its capacity to create new knowledge and widely disseminate it, significantly expanding the opportunity for innovation. Secondly, the knowledge-based economy does not depend on finite factors of production, and this opens possibilities for development to any economy searching for a development strategy, provided that the economy has supportive and strong leadership and can obtain funds to build the technology infrastructure, even if the education system has not yet developed to the ideal level. Younger generations' demands to use the technology will eventually shift social perspectives. While economic agents must have incentives for efficient use and creation of knowledge (Chen and Dahlman, 2005) to stimulate innovation, this incentive can come from outside national borders through ICT. There is no one blueprint that fits all situations because the sociocultural environment determines not only policy development and implementation but also the receptiveness to change that occurs in a knowledge-based economy.

We now move on to economic growth theory concerning knowledge as an infinite factor of production on which new knowledge is built. Issac Newton used this phrase (although he was not the first to introduce the concept), "If I have seen a little further, it is by standing on the shoulders of Giants" (Newton, 1676), meaning using the knowledge of those who have gone before in order to create new knowledge and not reinvent the wheel.

## **2.5 Economic Theory**

The relationship between growth and technological and organizational innovation has been extensively examined and debated in economic theory. (See authors in this section.) As it became more obvious that the unexplained portion of growth in the production function was very high, the relationship between technological change and growth received increasing attention. While classical economists placed technological change at the core of economic growth, exogenous growth theory placed technology outside the growth model. This section traces economic growth theory from the development of Solow's exogenous growth model (1956) to Romer's endogenous model (1990) to evolutionary theory (Edquist, 2005). Our search through economic theory is to determine the theoretical base for innovations systems, and evolutionary theory offers a foundation for innovation systems thinking.

### ***2.5.1 Exogenous Growth Theory***

Economic theory states that an economy's output, or GDP, depends on its input factors and its production function. Until the 1950s the two most important input factors were capital and labour. The quantity of capital and labour, coupled with Total Factor Productivity (TFP) that represented how they were used, determined the output (Samuelson and Nordhaus, 2010). From this basic model it could be determined that changes in any of these factors or processes affected output quantity and could lead to growth (Samuelson and Nordhaus, 2010). Changes could occur in quantity or use of capital, quality or quantity of labour, or a production function that incorporated technological change.

Economists of the 1950s credited technological change or TFP as the factor that substantially increased output per worker (Abramowitz, 1956; Solow, 1956). The Solow model (1956) introduced a model that included technological progress as an exogenous force in the production function, and thus it did not address how technology might interact with and influence other factors of production. Subsequent research pointed to the importance of increases in the effectiveness of labour and capital stock in creating growth in output per worker (Jorgenson, Gollop, and Fraumeni, 1987). The contribution of technological change, as the residual left unexplained when capital and labour had been accounted for, varied over time.

### ***2.5.2 Endogenous Growth Theory***

Romer (1990) concluded that Solow's neoclassical growth theory offered two basic factors of production: technology and the conventional inputs of physical capital, labour, and human capital. The theory, however, did not capture the essence of what technology meant nor how it could lead to a leap forward in economic development. Romer defined an endogenous growth model that introduced technology as a determinant and showed how it interacted with production to produce growth. For example, investing in knowledge acquisition through technology could lead to a quality change in labour as well as capital, which would affect economic growth. Technology could be described as routines followed within firms, and technology's role lay in inventing new routines and recipes, prescriptive knowledge, and more importantly, making them available to all (Nelson and Winter, 1982). Whereas traditional economic theories emphasized savings and investment levels and population growth, endogenous growth models emphasized the non-traditional factors: human capital, the accumulation of knowledge and new ideas, producer innovation, research and development, and externalities in ties to the global economy (Lundvall, 1996).

Romer (1990) made his argument based on three premises. First, technological change, or improvement in the processes or instructions for mixing raw materials, was the core of economic growth. He surmised that technological change was incentive for capital accumulation, which, with technological change, increased productivity. His second premise was that most technological change was an outcome of intentional actions taken by individuals who responded to market incentives. While initial research and invention could be conducted for their own reward, they were translated into practical goods through market incentives. This made technological change endogenous to the production function. A third premise was that technological change, as an entity, had different attributes than other economic goods. Once the cost of new technology had been paid, it could be used repeatedly without additional cost. This related to the concept of economic goods. An economic good was considered to have two fundamental properties: its level of rivalrous and its excludability (Cornes and Sandler, 1984). A rival good had the attribute that if it was used by one entity it could not be used by another. Traditional factors of production, for example, or conventional goods were rivalrous. A good was excludable if its owner could prevent others from using it. The source code of a software application could be excludable if it was copy protected or legally protected through an intellectual property system. In general, most rival goods are excludable. However, technology, as new recipes, was a nonrival input. Romer (1990) provided an example of a design, which was non rivalrous, as opposed to the ability to add, which could be considered human capital, and was rivalrous and excludable. However, the design could be copyrighted or protected in some way such that it could be used over and over and yet the owner would gain rent through intellectual property (IP) protection. The cost of copying the design was negligible, but the cost of training a person to add was the same as the cost of training the first person.

Technological change most often takes place because of actions of self-interested firms or individuals (premise 2) and therefore necessarily must provide benefit to the firm or individual. To provide benefit, however, the technology must be partially excludable. The applicability of this concept to economic growth theory is that while knowledge of an individual is rivalrous, an individual's design or mathematical proof is a nonrival good, and knowledge can be considered to be nonrivalrous and yet excludable. If a nonrival input has productive value, then output cannot be a constant-returns-to-scale function of all its inputs together (Romer, 1990). The point Romer made is that given a production process in which there are rival inputs and nonrival inputs, both of which are productive, the production function cannot be a price taker. Products would sell for marginal cost, and the firm would suffer losses.

Other economists addressed Romer's premises in various ways. Solow (1956) treated non-rival inputs as an exogenously provided public good. Shell (1967) treated nonrival inputs as public input provided by the government, which did not seek compensation. Their theories contradicted Romer's second premise, the role of profit maximizing behaviour in technological change. Arrow (1962a) attempted to make non-rival inputs responsive to market incentives stating that an increase in capital would necessarily lead to an equal increase in knowledge through learning-by-doing. Lucas (1988) assumed that production of human capital rather than physical capital generated this nonrival, non-excludable good. Shell proposed a model with price taking in which expenditure on research was compensated out of quasi-rents. Griliches (1979) assumed that the production function contained an excludable and a non-excludable part of the benefits of research and development.

Romer (1990) concluded that if his three premises were met, then equilibrium with price-taking behaviour could not be met. He proposed a model in which a firm incurred fixed design research and development costs when it created a new good and then recovered the costs by selling at a price higher than its constant cost of production. The four basic inputs in his model were capital as consumption goods, labour as physical body skills, human capital as education and on-the-job training, and an index for the technological level. The model separated the rival component of knowledge, human capital, from the non-rival component, technology. Technology could grow without bounds because it had an existence separate from an individual. Roomer's model, an extension of the Cobb-Douglas, was as follows:

$$Y(H_Y, L, x) = H_Y^\alpha L^\beta \sum x^{1-\alpha-\beta} \quad (1)$$

Where:

$H_Y$  = human capital

$L$ =physical labour

$x$  = list of inputs, including  $A$  or technology

The list of inputs,  $x$ , could only be those that had already been invented and would change as more inventions took place. (See Romer, 1990, for detailed assumptions and limitations about his model.)

A second contribution from Romer's work (1990), important for invention, was the output of the researcher, referred to as the ideas production function. Romer maintained that anyone engaged in research could have free access to the entire stock of knowledge, given that knowledge was a nonrival input. Therefore the aggregate stock of designs or new knowledge was:

$$\dot{A} = \delta H_A A \quad (2)$$

Where:

$\dot{A}$  = the rate of new ideas production

$H_A$  = the number of ideas workers or researchers

$A$  = the stock of ideas available to these researchers

This made the rate of technological change endogenous in two distinct ways. First, the share of the economy devoted to the ideas sector was a function of the R&D labour market (which determined  $H_A$ ), and allocation of resources to the ideas sector depended on R&D productivity and the private economic return to new ideas. Second, the productivity of new ideas was sensitive to the stock of ideas discovered in the past. There has been debate over the exact value of these parameters (Jones, 1995; Porter and Stern, 2001) and the form and equilibrium logic of the model (Dosi et al., 1988; Grossman and Helpman, 1991; Kortum, 1997), but there is consensus that these factors are crucial to an explanation of an economy's innovation capability (Stern et al., 2002). The concept that knowledge and research are nonrivalrous indicates that they do not compete but rather build on each other. Once research is completed, a next step is to build new knowledge or invention based on what is known.

Implications of Romer's models were important for determining key factors for growth. One point he emphasized was that spillover and price setting were important in depicting the characteristics of knowledge in an economic growth model because without these two elements innovation's usefulness to society would be limited. It was expected that fixed costs led to gains from trade between countries, while the static theory of trade with differentiated goods indicated that fixed costs led to gains from trade between countries (Helpm and Krugman, 1985). The real value of larger markets lay in inducing more research. The relevant measure of market size lay in the stock of human capital, which did not depend on the size of the labour force. A doubling of human capital and the stock of knowledge could lead to an increase in the marginal product of human capital in research. Romer's model also indicated that research had positive external effects. An additional design raised the productivity of all future individuals who did research (Romer, 1990). Economic growth, then, was dependent on human capital and its expansion through research, education, and innovation, not just on an increase in population.

Endogenous growth theory provided the theoretical framework for understanding the role of technology on growth in its influence on the production function and its influence on labour.

According to economists, technology as TFP, a large part of which is attributable to technological



change, explained much of the difference in level and rate of economic growth across countries (Abramovitz, 1995; Easterly and Levine, 2001; Hall and Jones, 1999; King and Levine, 1994). The theory also pointed to the role of human capital development in economic growth and was a predictor of the role of innovation.

### **2.5.3 *Measuring Growth - Growth Accounting***

Growth accounting is economists' attempt to decompose economic growth into components of factor inputs and a residual that reflects technological progress and other elements not explained by factor inputs. It is generally the first step in analyzing determinants of economic growth. The final steps examine the relationship of growth rates, factor shares, and technological change to other elements in an economy such as government policies, human capital, natural resources, consumer preferences, and similar entities (Barro, 1998). The impetus for the development of growth accounting lay in the fact that neoclassical growth models assumed diminishing returns in physical capital, and if correct, this indicated that capital accumulation could not sustain long-term growth. TFP could. However, TFP inherited errors in measurement as well as new ways of constructing buildings, newly-invented machines, new sources of power, changes in work organization, literacy and skills of the workforce, and in many other factors (Simlali, 1999).

The basics of growth accounting were addressed by Solow (1957), Kendrick (1961), Denison (1962), and Jorgenson and Griliches (1967). Solow (1957) attempted to clarify growth in his model in terms of the distinction between shifts of and moves along the aggregate production function. The residual would capture any kind of shift in the production function. He later proposed an alternative in which he assumed that technical change was embodied in new types of capital. Denison (1962) developed an approach that included the contribution of labour quality, by measuring the effect of education on earnings, and thus reduced the contribution of the residual to a little less than half. Denison made an assumption that economies of scale were responsible for about half of the remaining residual. Jorgenson and Griliches (1967) focused on measuring capital services and produced a much more sophisticated index of capital input growth, while also correcting labour quality for changes in education. Later attempts used more categories. Table 2.2a summarizes the early studies.

The recent studies (Table 2.2b) were conducted in the era of new growth economics. The methods used by economic historians in accounting for the residual did not change much (Crafts, 2009). In two cases R&D was treated as a factor of production. In two other cases, the Denison (1962) approach to adjusting labour inputs for educational quality was updated by the augmented Solow

approach of treating human capital as a separate factor in the production function. Rossi and Toniolo (1992) employed econometric methodology to estimate the true contribution of technical change to TFP growth by correcting for fixed factors of production, adjusting costs, and scale economies. While the authors in general believed that TFP growth was partly a reflection of technical change, other sources were still open to question. The residual could be attributed to some combination of labour quality, improved allocation of resource, changes in the way factors or production were used, reduction in technology gaps, and economies of scale with a small unexplained portion.

**Table 2.2a – Early Studies**

Study	Education	Work Intensity	Capital Quality	Embodied Technical Change	Increasing Returns to Scale	Structural Change
Carre et al.. 1975	X		X			X
Ohkawa and Rosovsky 1972	X		X			
Abramovitz and David, 1975	X		X			
Mathews et al.. 1982	X	X				
Bergson, 1985	X				X	X
Maddison, 1987	X		X	X	X	X

Source: Crafts, 2009

**Table 2.2b – Recent Studies (in the era of new growth economics)**

Study	Education	Human Capital	Capital Quality	Embodied Technical Change	Research and Development	Capacity Utilization
Rossi and Toniolo 1992						X
Van Ark and de Jong 1996	X				X	
Abramovitz and David 2001	X		X	X	X	
Lains 2005		X				
Schulze 2007		X				
Prados and Roses 2007	X		X			

Source: Crafts, 2009

Growth accounting offers two messages relative to modern economic growth. First, the idea that capital accumulation can cause a take-off into sustained economic growth is a misunderstood phenomenon of the Industrial Revolution. Second, major technological breakthroughs do not have a

dynamic effect on economic growth at the aggregate level (Crafts, 2009). Research has confirmed that TFP growth is a more important source of labour productivity and physical capital productivity (Crafts, 2009).

Recent theories of endogenous growth have implications for the modeling of the relationship between technological change and R&D. Specifically, the residual can be interpreted within settings that permit increasing returns and spillovers, and in models in which technological progress is generated by purposeful effort. Standard growth accounting exercises provide useful information for modern theories of endogenous growth, which offer a clearer perspective on the residual, and recent theories can be used to extend the usefulness of traditional growth accounting: the older and newer approaches to economic growth are complementary (Crafts, 2009).

#### ***2.5.4 Evolutionary Theory***

Whereas in neoclassical growth theory cause and effect are separate and occur in a steady state phenomena, evolutionary theory addresses complex causal factors that change over time and exhibit turbulence that is associated with the innovation process. Neoclassical growth theory and evolutionary theory agree on the importance of innovation, technology, and government policy in its contribution to economic growth but disagree on the behavioural foundations of growth (Edquist, 2009).

Evolutionary growth theory is neo-Schumpeterian in its approach. Growth models focus on technical change as the driving force of the evolutionary process. The explanation of performance is based on selection and generation of novelty. New growth models differ in whether they use a micro or macro foundation and therefore, in their interface with firm strategies and markets (Edquist, 2009). What follows is a brief description of evolutionary growth models, starting with Nelson and Winter's (1982) work, which is considered a foundational contribution to the field.

Nelson and Winter (1982) used the same dataset as Solow to determine if their outcome was similar to his outcome based on neoclassical theory. If outcomes were similar, then evolutionary theory could not be discarded. In their model, heterogeneity was defined by firms using production techniques that employed a fixed ratio of labour and capital and homogenous output. Over time technological change could produce a phenomena that resembled substitution between labour and capital. Novelty occurred because of a firm's search activities for new techniques or imitations of techniques employed by other firms. In both cases the search would be due to the firm's rate of returns falling below a specified arbitrary level. Nelson and Winter argued that evolutionary theory,

while explaining the same empirical trends, did not depend on a production function, which in the neoclassical interpretation was based on moving along an existing production function or shifting to a new one.

What followed were attempts to found models at the macro level. These included Conslick, 1989; Vespagen, 2005; Silverberg and Lehnert, 1995; and others. The most important commonality among these models was the role of technological differences among levels, sectors, and countries. The differences were continually modified by a selection process that provided the driving force for economic growth. There was no standard set of assumptions or common results. For example, Conslick (1989) believed that the growth rate was a function of average innovation size, rate of savings, and the speed of diffusion of new knowledge. The savings rate did not have an impact on long term growth, whether using Solow's exogenous technical change or Arrow's learning-by-doing.

Other models were based on firm behaviour and founded in microeconomic theory. These models included Dosi and Nelson, 1994, and Silverberg and Verspagen, 1994. All assumed that technological differences were the source of differences among firms, and firms adopted process innovations as the source of technological progress. The models also offered a second source of divergence in the form of behavioural differences among firms. These could be in terms of R&D strategies, pricing, or other business strategies.

Evolutionary theory took into account that R&D was basically stochastic, and technology flows in the long run were important for economic growth. Context and historical circumstances played a large role, and causal mechanisms in one period could be subject to endogenous change in the next (Edquist, 2009). Evolutionary theorists could not subscribe to Solow's production function, which included technology as an exogenous force in production. Romer (1988) and Grossman and Helpman (1991) made technology endogenous by modelling the R&D process. The spillovers in endogenous growth could lead to increasing returns to scale. Evolutionary theory and neoclassical theory have converged in what is central to growth but disagree on nature of the growth process. They share the importance of technology, but new growth offers the possibility that the relationship between technology and growth can be affected through policy.

## **2.6 Innovation Systems**

In this section a brief discussion of innovation and past theoretical approaches to innovation systems is followed by an examination of innovation systems. This leads to a discussion of National

Innovation Systems and the actors, institutions, and links that make up the system. A section on how innovation can be measured provides a preliminary guide to measurements that will be used in the regression analysis later.

### **2.6.1 The Concept of Innovation**

Schumpeter (1996: 87) conceived innovation broadly by using the production function, which “describes the way in which quality of product varies if quantities of factors vary”. Varying the form of the function instead of the quantities resulted in innovation. Schumpeter defined innovation as a new combination of existing resources, and this combination was created by entrepreneurs. After he moved to the U.S., his concept of entrepreneurs as the source of innovation shifted to a belief in large scale enterprises as a source of innovation (Schumpeter, 1996).

The many facets of innovation have been defined by business and economic scholars in addition to Schumpeter. “Innovation is...novelty...the creation of something qualitatively new” (Smith, 2005: 149). Innovation is the attempt to take invention, which is the first occurrence of a new idea or process, and put it into practice (Rogers, 1995). The role of the innovator, the person or organizational unit responsible for combining factors (Fagerberg, 2005), called the entrepreneur by Schumpeter (1950), is radically different from the inventor. As conceived by Nelson and Rosenberg (1993), innovation is technical innovation, process and product innovation. It is the process by which the firm masters and puts into practice processes that are new to them. In this way, their definition includes technology and its diffusion. They indicate that the inventor or first firm to bring a new product to market is not necessarily that one that captures the most economic rent (Nelson and Rosenberg, 1993). As described by Edquist (2005:182), innovation includes “product innovations: new or better material goods as well as new intangible services and process innovation: new ways of producing goods and services-technological or organizational.” A distinction is also made in the literature between incremental and radical or disruptive innovation. Liefer and his colleagues made important contributions to literature in differentiating the two. Radical innovation “concerns the development of new businesses or product line based on ideas or technologies or substantial cost reductions – that transform the economics of a business and therefore requires exploration competencies” (Leifer et al., 2000: 5). Incremental innovation is short term, follows a linear and continuous path from concept to commercialization, with idea generation occurring at the front end of the process (Leifer et al., 2000). The latter involves making small improvements, while the former may be the introduction of a totally new process or machine (Anderson and Tushman, 1990; Freeman and Soete, 1997).

While innovations are primarily associated with high technology and implementation of scientific breakthroughs, innovation can also occur as a result of the development and generalization of business practices (Kravchenko, 2011). Rosenberg (1976) questioned whether research-based discovery was necessarily the preliminary phase of innovation. He emphasized that innovation was not a linear process, that the learning process involved multiple inputs, and that innovation did not depend on invention as the initiator.

In this study, innovation is conceptualized as:

- New knowledge or a new combination of existing knowledge.
- Technologically-based and extended to processes, products, and services.
- Not necessarily starting with research-based discovery.
- Disruptive and/or incremental.
- Non-linear but interactive and circular.

### ***2.6.2 Theoretical Origins and Approaches to Innovation Systems***

Lundvall suggested that a brief investigation of List, Freeman, Nelson, and Porter could provide a background for the theoretical approaches to the study of innovation systems (Lundvall et al., 2002).

While Freeman was considered the first to mention innovation systems in literature (Nelson, 1987), List (Senghaas, 1991) anticipated many contemporary ideas about national systems of innovation. His analysis included education and training institutions, science, technical institutes, user-producer interactive learning, knowledge accumulation, adapting imported technology, and promotion of strategic industries. He also emphasized the role of the state in coordinating and carrying through long-term policies for industry and the economy (Nelson, 1987). List's system, the National System of Political Economy, offered a perspective based on productive forces, including:

- Recognition of the interdependence of tangible and intangible investment
- Industry should be linked to the formal institutions of science and of education
- Recognition of the interdependence of the import of foreign technology and domestic technical development. Nations should not only acquire the achievements of other more advanced nations, they should increase them by their own efforts.
- Protection for infant-industries (Lundall et al., 2002)

He advocated a broad range of policies designed to accelerate industrialization and economic

growth. Most of these policies were concerned with learning about new technology and applying it (Freeman, 1987). List concluded that it was intangible investment in knowledge accumulation that was decisive in production rather than physical capital investment. Thanks to the advocacy of List and like-minded economists, Germany developed one of the best technical education and training systems in the world (Prais, 1981). This and his argument for “infant industry” protection were his legacies (Lundvall et al., 2002).

Building on the work of List, Freeman (1987) defined innovation systems as “the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies.” (1). Freeman’s analysis centered on the organization of R&D, production in firms, inter-firm relationships and the role of government, specifically Ministry of International Trade and Industry (MITI) in Japan. In the 1950s and 1960s, Japanese success had been attributed to copying, imitating and importing foreign technology and statistics were often cited to support this view (Freeman, 1987). It was later determined that the role of government, links between firms, and the high concentration of R&D in fast growing industries were the crucial factors in Japan’s success. Patent statistics showed that the leading Japanese electronic firms outstripped American and European firms in these industries, not just in domestic patenting but also in patents taken out in the United States (Freeman, 1987; Patel and Pavitt, 1994). Freeman found that while industrialized countries made large investments in R&D in the 1950s and 1960s, the rate of technical change and economic growth depended on social innovations, as much as technical innovations, and more on diffusion than on being first in the world in radical innovations (Freeman, 1995). While the measures of research and innovation indicated that there was a large increase in Japanese scientific and technical activity, the connection between this activity and higher product and process quality (Womack, Jones and Roos, 1990) and shorter lead times (Graves and Jordan, 1991) was not made. Nor was this activity connected to rapid diffusion of technology. More studies on Japanese production demonstrated that tacit knowledge was partially responsible for the incremental innovations that improved quality and processes (Nonaka and Takeuchi, 1995). Freeman focused on the interaction between the production system and innovation. He applied a combination of innovation and organizational theory to determine which organizational forms were most relevant to the production and use of technology (Lundvall et al., 2002).

While Freeman focused on the interaction between innovation and the production system, Nelson (1987) was more interested in knowledge production and innovation in the narrow sense. Nelson studied U.S. systems and focused on the role of firms, government, and universities in the

production of new technology. He found that different industrial sectors used different methods to gain benefits from their innovations. Technological change could be understood as an evolutionary process in that innovation continues to produce entities superior to those in earlier existence and an equilibrium state is never reached (Nelson, 1987, 1995). Therefore, technological change is open-ended and path dependent (Edquist, 1997).

Lundvall and others (2002) argued that Porter's *Competitive Advantage of Nations* (1990) was a work on national systems of innovation in that it referred to the determinants of competitive advantage as a system and the level at which it worked was national and local. Porter (2000) claimed that: "Competitive advantage is created and sustained through a highly localized process. Differences in national economic structures, values, cultures, institutions and histories contribute profoundly to competitive success." (3). The localized advantage that he referred to were clusters, "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions... in a particular field that compete but also cooperate." (4). He claimed that clusters were a noticeable feature of virtually every national, regional, state, and even metropolitan economy, especially in more advanced nations.

Lundvall et al. (2002) based his work on the systems approach on the assumption that if knowledge was the fundamental resource then learning must be the most important process for innovation, and learning was an interactive and socially embedded process, which must be understood in its institutional and cultural context. Lundvall and his colleagues in the Aalborg approach stressed processes of learning and user-producer interaction, which seemed to fit incremental technological innovations better than discontinuous ones (Lundvall et al., 2002). Their investigation started with the systems of production and then the role of home-market in economic specialization. This process led the group from innovation as an individual effort to innovation systems, which included the role of institutions and institutional economics (Lundvall et al., 2002). This thinking foreshadows the intent of this research in determining the role of sociocultural dimensions in innovation systems.

### **2.6.3 Innovation Systems Perspective**

Innovation activities are interactive in that key actors are linked with each other and depend on an infrastructure outside their environment. For this reason economists and academics of other persuasion have applied a systems approach to the study of innovation (Carlsson and Stankiewicz, 1991; Freeman, 1982; Lundvall, 1992; Nelson et al., 1993). The term, systems of innovation, was



first published as “the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies” (Freeman, 1987: 1). Innovation systems can be narrowly equated with innovation in science and technology, which takes into account indicators of national specialization and performance in innovation, research and development efforts (Mowery and Oxley, 1995). A broader perspective encompasses learning, innovation, and competence building at different levels and takes into account social institutions, macro economic regulation, financial systems, education and communication infrastructure, and market conditions (Gu and Lundvall, 2006).

Lundvall (1992) and Nelson (1993) further discussed the concept, using the same term but differing in the determinants they saw as the most essential. (See paragraphs above.)

Regardless of the focus, the minimal characteristics of a system (Edquist, 2005) include:

- A function or objective
- Boundaries: it can be differentiated from what is outside the system.
- Two parts: the components and the links between them, and the two parts create a whole.

The primary objective of an innovation system is to pursue innovation processes. It can be assumed that a secondary objective is to gain a better understanding of the role of innovation in economic growth and national production systems, innovation as an interactive process in the micro sense, and the role of institutions in shaping innovative activities (Lundvall et al., 2002).

In terms of boundaries, the terminology, “systems of innovation”, has been used to refer to national, regional (Braczyk and Heidenreich, 1998; Asheim and Isksen, 1996), and sectoral (Breschi and Malerba, 1996) systems. Sectorally, the literature refers to firms involved in developing the same product types or using the same technological system (Breschi and Malerba, 1996). Sectors are considered to be somewhat socially constructed and difficult to determine because of technological shifts (Edquist, 2005). Also, even when sectoral boundaries are used, they are geographically delimited.

A regional perspective builds on the importance of regions for network development and new technology systems, which have been emphasized by geographers and economists (e.g. Lundvall, 1992; Saxenian, 1991; Storper and Harrison, 1991). Local infrastructure, externalities, especially in skills and local labour markets, specialized services, and personal relationships contribute to

regional vitality. Also, regional systems of innovation and economies of agglomeration have underpinned national systems from the beginning of the industrial revolution (Arcangeli and Canuto, 1996). Marshall (1890) had already stressed the importance of industrial districts, and Piore and Sabel (1984) specifically underscored the importance of regions in many parts of Europe, both in the nineteenth century and the modern era.

A national system of innovation is delineated by national boundaries. Policy makers and researchers, when considering whether to apply national or regional boundaries, make the selection based on which boundaries allow the greater understanding and management of the innovation effect. Geographical boundaries affect localized learning spillovers among organizations, the mobility of labour within the region, and localized networks that facilitate interaction. However, innovation policy is usually made by, and more importantly implemented by, national governments and from a policy perspective, National Innovation Systems seems the most relevant boundary. Porter (2000) claimed that the intensification of global competition made the role of the home nation even more important, partly because national policies for catching up in technology were of fundamental importance in supporting innovation.

While defining the objective of a system of innovation and determining the boundary for its study are relatively uncomplicated tasks, pinpointing the determinants of these systems, how they interact, and how they might be measured is more complex. Thus, there are various taxonomies on how the components and links between them should be determined.

The main components of innovation systems are considered to be organizations and institutions. “Organizations are formal structures that are consciously created and have an explicit purpose” (Edquist and Johnson, 1997: 66-67), such as firms, universities, and public agencies. “Institutions are sets of common habits, norms, routines, rules that regulate interactions among individuals, groups, and organizations” (Edquist and Johnson, 1997: 66), which are the rules of the game. Just as significant national differences exist among economies, so organizations and institutions vary. To further categorize components, academics attempted to provide an explanation of innovation system activities as the actions related to “the creation, diffusion, and exploitation of technological innovation within a system” (Liu and White 2001: 1093). These included R&D, implementation, end-use, education, and linkages among them.

While one way to consider innovation systems is through its organizational components, another is

a functional approach from Edquist and others (Galli and Teubal, 1997; Liu and White, 2001; Rickne, 2000). Bergek and Jacobsson (2003) suggested that an innovation system could be described in terms of the functions they served and offered five functions: innovation, guiding the search process direction, supplying resources, creating positive external economies, and facilitating market formation of markets. Actors would therefore be those who performed functions. Edquist (2005) believed that studying the causes of innovation was relevant to understanding the activities of innovation and offered a list of eleven activities as part of the process. Among these activities were R&D to create new knowledge, competence building, articulation of quality requirements, networking, creating and changing organizations and institutions, and other functions that were part of running a successful business in the modern global economy. Lundvall (2002) questioned the functional approach and offered a third approach. His approach focused on the innovation process, drew innovation theory based on stylized facts, and was rooted in an evolutionary perspective. In their attempts to define and categorize what does not lend itself to such boundaries, academics may have over-complicated a process that happens creatively and can be brought to fruition through investments from whatever sources.

Theory is still being formed, but what cannot be disputed is the relevance of learning that builds human capital to innovation in an economy. Edquist (2005) offered three kinds of learning: (1) innovation, which he claimed is organizational learning and is an asset of firms, (2) R&D carried out in public research organizations and universities, and (3) competence building, which is training and education that takes place in schools and universities and is individual learning. Considering these three kinds of learning and understanding their relationship may lead to the most appropriate determinants of an innovation system.

Whether taking an organizational, functional, or process approach to the study of innovation systems, a framework that discusses actors, institutions, and links between them lends itself to all three approaches and will guide the discussion on National Innovation System in the next section.

## **2.7 National Innovation Systems**

National Innovation Systems (NIS) provides the most relevant boundary designation for this investigation because of policy implications. As previously stated, innovation policy is implemented by national governments. The GCC, as a boundary, is a loose one, and while economic policy can be made at its regional level, the power to implement is through suggestion

and voluntary adoption on the part of the individual countries, rather than legal. Therefore, the following discussion refers to components within a national setting.

### **2.7.1 Actors**

#### **The Firm**

Innovation systems literature claims that innovation takes place mostly in firms because of the requirement of the firm's resources in knowledge, capabilities, and skills (Lazonick, 2005). How then does the firm generate innovation out of invention and gain from its innovation in seeking profit? The ability to do this, a firm's core competency (Nelson, 1991), requires that a firm engage in three fundamental activities: strategizing, financing, and organizing (Lazonick, 2005). While an immense body of literature has been written on each of these three activities, the intent here is to focus on how each activity contributes to producing innovation.

A firm's strategy sets the path along which it intends to move and emphasis in business literature focuses on finding a path that reaches business objectives while remaining flexible enough to be modified when circumstances require. According to Michael Porter,

there is an infinite number of possible strategies even within the same industry. No tool can remove the need for creativity in selecting the right strategy. Great companies don't imitate competitors, they act differently ... we do need to discover how the process of creativity takes place" (quoted in Pettigrew and Whipp, 2001: 111).

Bean and Radford (2002: ix) believe that "survival, continuation, and success are the reward of a company having a commitment to innovation." Practical implications of this commitment may require the creation of new markets in uncharted territories, although a more common practice is for the company to match and beat a commercial rival, through incremental improvements in cost or quality, or both (Pech, 2005). Christensen and Raynor (2003: 221) found that being open to emergent strategy enabled management to act before understanding all implications. The term emergent strategy "implies learning what works – taking one action at a time in a search for the viable pattern or consistency". What is critical in creating strategy is the ability, incentive, and vision of a manager to meet changes required by the innovation process and intercede before they occur. The innovation systems perspective on sharing knowledge, while a worthy ideal, seems a contradiction to literature on business strategy and requires careful analysis on the part of policy makers to consider up to what point firms will be willing to share technology and new knowledge that are part of the firm's core competency.

A second characteristic of innovative firms is the firm's choice of product development projects or R&D to fund and more generally, how financial decisions are made. Schumpeter (1950), in his concern with characteristics of innovative activity and resource allocation and structural economic change, emphasized the importance of finance in fuelling innovation. Research of financial economists and innovation economists seem to be based on different theories. For financial economists, economic decision-making is a world that is deterministic, and rational decision-making can be determined through probabilistic estimates. For innovation economists, no objective guidelines exist for making innovation investment decisions, and as innovation occurs, new processes evolve (Kline and Rosenberg, 1986; Rosenberg, 1996). For innovation economists the fundamental uncertainty of investment in innovation indicates that decisions must be made on subjective judgments and perceptions and belief systems. Actually, these decisions are made on experience in the industry and knowledge of the fundamental technologies, and the basis of these decisions is more akin to tacit knowledge, which cannot be successfully taught (O'Sullivan, 2011). Given that funds or investment are a crucial factor in propelling innovation forward, if policy bodies intend to persist in creating national systems of innovation, empirical research based on innovative companies and individuals may be more effectively conducted by business researchers than economists.

The third element of an innovative firm lies in the organizational integration that determines innovative capability (Lazonick, 2005). The relationship is dynamic and complex, and the literature addressing the relationship is large and diverse. This does not necessarily indicate that it is the most important of the three functions: strategizing, organizing, and financing. Rather, it seems to have attracted the interest of a multitude of scholars, a few of which will be mentioned here.

The topic can be examined from three perspectives: the relationship between organizational structure and innovation, innovation as an organizational learning and knowledge creation tool, and organizational ability to adapt to change. The classical theory of organizational design depends on contingency theory, which explains diversity in organizational form in reference to the demands of context (Lam, 2005). The most relevant structure for an organization depends on its operating contingency, such as scale of operations (Pugh et al., 1969), technology (Woodward and Wedderburn, 1965) or environment (Burns and Stalker, 1961). An important contribution based on contingency theory was a synthesis of other work stating that five archetypes are the basis of firm organization and each offers innovative potential: simple structure, machine bureaucracy, professional bureaucracy, divisionalized form, and adhocracy (Mintzberg, 1979). Contingency theory-based thought indicates that as technology becomes more complex and uncertain,

organizations will adopt more flexible structures and move towards more organic forms of organization.

The work by economists on organizational structure focuses on how interaction between market and organizational factors affects innovation. Organizational structure is both caused by and effects strategic choice in response to market opportunity (Lam, 2005). The theory of innovative enterprise (Lazonick and West, 1998) focuses on how strategy and structure determine competitive advantage and how business enterprises in advanced economies must achieve organization integration to remain competitive.

Organizational researchers emphasize innovation as a learning and problem-solving process. The approach defines an innovative organization as intelligent and creative (Glynn, 1996), capable of learning effectively (Senge, 1997), and creating new knowledge (Nonaka and Takeuchi, 1995). The approach is based in cognitive psychology, which theorizes that individuals develop mental models and structures they use to perceive and construct to make sense of the world and make decisions and take actions based on this model (Walsh, 1995). Of recent importance are high performance work systems or lean production (Womack et al., 1990) and the N-form corporation (Hedlund, 1994). Others include cellular forms (Miles et al., 1997) and modular forms (Galunic and Eisenhardt, 2001). The studies emphasize how firms create learning organizations capable of innovation. Much of this literature contrasts the patterns of innovation and technological change in different countries and attributes the differences to national institutional frameworks and how they shape organized forms and innovative competencies (Whitley, 2000, 2003; Hollingsworth, 2000). Generally economists and evolutionary theorist have taken into account the relationship between innovation and organizational evolution at the population or industry level, while organizational and management researchers examine the process of adaptation at the individual organization.

Recent models of innovative organizations are of two fundamental and contrasting types: the J-form and adhocracy. The J-form (Nonaka and Takeuchi, 1995) believes that knowledge creation takes place within the organizational community; knowledge is embedded in a firm's team relationships, culture, and operating systems. The models adaptability to innovation in rapidly changing technology fields has been questioned (Lam, 2002). In the adhocracy model learning and new knowledge come from experts with diverse skills being placed on ad hoc teams to solve complex problems. The approach is subject to loss when highly skilled individuals leave the firm (Lam, 2005).

Because innovation is uncertain, it involves learning through experimentation and improved

understanding (Pavitt, 2005). While strategizing, financing, and organizing form the dynamic processes, learning is the outcome and understanding the learning processes provides the key to creating a theory of innovative enterprises. Understanding competence building and how it effects and is effected by strategy, financial decisions, and organizational structure is the fundamental challenge for the innovative organization.

## **Universities**

Education in its broader sense affects innovation productivity in four fundamental ways. First, as Griliches (1990) analysed, scientists are considered as input in the knowledge production function and output of the education production function. Therefore, a high quality education system with a science orientation, will lead to a larger and improved pool of scientists. Secondly, a highly skilled workforce is an asset that can be relatively fixed within a country's borders. The education and training system is responsible for the creation of this highly skilled workforce pool. Third, according to Lundvall et al. (2002), the subsystems of human resources development includes the formal education and training, the labour market dynamics, and the organization of knowledge creation and learning within firms and networks. Education helps to create a national pool of entrepreneurs who demand innovation, new products, and more efficient production methods, to gain competitiveness. Fourth, as noted, innovation networks include customers, and the role of demand conditions is a key driver for international competitiveness. The more sophisticated local customers are, the higher the probability local industries will develop international competitiveness (Porter, 1990).

Universities are being asked to play a role, in addition to teaching and research, in contributing to economic development. Since 1970, governments have attempted to more closely link universities to industrial innovation as part of a broader effort to increase economic development. Several frameworks or conceptualizations have been developed that demonstrate the role of universities in innovation. Table 2.3 summarizes these approaches. Each conceptualization emphasizes links among industry, academia, and government but lacks the criteria to assess the implementation of these links and how to measure the strengths.

**Table 2.3 Approaches to University-Industry links**

<b>Approach</b>	<b>Perspective</b>	<b>Source</b>
Linear model	Outcome of university research is critical to economic growth. Funding of this basic research in universities was necessary and sufficient	Bush, 1965
Contrasting norms between academic and industrial research	Disclosure norms differ between academia and industry. Academia requires disclosure to gain peer credibility; industry is more secretive and requires limited disclosure, and perhaps mislead competition.	Dasgupta and David, 1996; David, Foray, and Steinmuller, 1999
Mode 2	Subscribes to an interdisciplinary, pluralistic, networked innovation system in which corporate and academic research institutions are closely linked.	(Gibbons et al., 1996)
Triple Helix	Emphasizes increased interaction among institutional actors. Each takes the role of the other: universities play entrepreneurial role and industry takes on academic role of sharing research knowledge.	Eskowitz and Leydesdorff, 1997

While Table 2.3 demonstrates a variety of models, Triple Helix dominates contemporary discussion on the respective roles of university-government-industry and will therefore be discussed in greater detail.

Triple Helix incorporates three aspects of current thinking: (1) universities playing a more prominent role in innovation, at the level of industry and government; (2) collaborative relationships among the three institutional spheres so that innovation policy is an outcome of



interaction of the three rather than a dictate of the government; (3) each institutional sphere performs new roles of the other two as well as their traditional functions (Etzkowitz and Leydesdorff, 2000). Asking institutions to play non-traditional roles can be a source of innovation in perspective

At the beginning, each entity operates in its traditional role: industry is the locus of production; government is the source of contractual relations, guaranteeing stability in interaction and exchange; and the university is a source of new knowledge and technology. In the Triple Helix paradigm, universities are expected to generate industry worthy knowledge and be responsible for its transfer through entrepreneurial endeavours. As firms raise their technological level, they engage in higher levels of training and in sharing of knowledge. Governments become public entrepreneurs and venture capitalists (Mowery and Sampat, 2005).

The ultimate goal in the paradigm seems to be to create a global innovation capability rather than the current international competitive environment. There are several issues that must be addressed in the paradigm. One is the concept in innovation business literature that competition raises the bar of expectation and results in new ways of thinking and higher quality (Porter, 1990). Why do championship level tennis players, Roger Federer and Rafael Nadal, welcome the opportunity to compete? They are both millionaires. Rather the excitement for both centres on improving their games in competition and raising their levels of play.

Another issue that must be addressed in the Triple Helix model is the difference in objectives of the three institutions and whether they may conflict. Organizationally, the modern university resembles more a cooperative than an industrial hierarchical structure, and the objective of the two differ remarkably. The university plays multiple roles and designating its primary role as research for industry may dilute the other, and perhaps more important, objectives, such as educating people. A firm is an economic institution, whose objective is to transform resources into goods and services for profit (Mowery and Sampat, 2005). Collaboration is beneficial if it is financially rewarding for both industry and academia and beneficial to government.

### **Research and Development Laboratories**

While the literature reveals that innovation does not necessarily start with R&D, it plays a crucial role in industry. R&D is conducted both publicly and privately and often participation of more than one entity is involved. Universities are the most important public entities performing R&D in most

countries and are the recipients of government funding and grants for advancement of knowledge (Mowery and Sampat, 2005). Public research labs, which are often funded by government departments and managed by research universities or firms, also play a large role in generating scientific knowledge. R&D performance and funding sources differ among developed countries, with much of R&D among wealthy countries being performed and financed by the private sector. Much of this R&D is development work rather than primary research and is driven by a quest for profits rather than advancement of knowledge (Mowery and Sampat, 2005). Literature suggests that because links between R&D entities, regardless of the R&D objective, are important in the performance of NIS, government can support collaborative centres and programs, remove barriers to cooperation, and facilitate the mobility of skilled personnel (Mowery and Sampat, 2005).

In the U.S. the Jet Propulsion Lab in Southern California (now part of NASA) is publicly funded and managed by the California Institute of Technology. The lab was successful in developing the Mars Rover, among other projects (Missions, n.d.). Multi National Enterprises (MNE) in the private sector, such as IBM and pharmaceutical firms have their own R&D labs. While sharing scientific research may allow faster-paced advancement in discovery, scientists within these firms are generally not allowed to share knowledge until it has been patented.

## **Government**

Government plays the role of actor in three fundamental ways: it provides funding, it sets policy, and it provides the economic and regulatory regime in which innovation and business take place. The economic and regulatory regime, as discussed under Knowledge-based Economy Infrastructure (2.4.2), applies to the requirements for NIS. Briefly, government should provide a competitive business framework, a stable financial sector, encourage business innovation through trade and investment, and promote labour market flexibility to allow skilled workers to flow to the most dynamic firms. Primary policy initiatives will be covered under Institutions, which provide the rules of the game. In funding, increasing national investments in innovation is essential to an economy's innovation capability (Abramovitz, 1956; Hall and Jones, 1999; Romer, 1990; Schumpeter, 1964; Solow, 1956). Government funding is country specific and can consist of funding for R&D labs as previously discussed, subsidies to specific industry sectors deemed valuable to innovation processes, and government guaranteed funds from financial institutions. Although government is being asked to play a role as a profit-seeking actor (Triple Helix model), it has not yet become significant in this role in most countries. Rather government profits through technology advancement relative to national defence and well being.

### **2.7.2 Institutions**

Institutions are defined as a set of common habits, routines, established practices, rules, and laws that regulate the relations between individuals and groups (Edquist, 2005). Institutions shape the behaviour of firms by constituting constraints and/or incentives for innovation (Arocena and Sutz, 2001). In NIS terminology, institutions are the rules of the game, and as such, have a major impact on how economic agents behave and on the performance of the system as a whole (Lundvall et al., 2002). Institutions may be informal rules and habits that are deeply ingrained in society (Lundvall et al., 2002). Many of these dimensions are cultural based and defined as sociocultural norms of behaviour and actions. Determining these dimensions is the primary objective of this research and will be addressed in the Section II – Sociocultural Dimensions of this chapter.

Formal institutions include the institutional framework set by government, as well as standards and policy set for industrial sectors by sector-specific or international regulatory bodies. The framework set by government is relative to the business climate in which firms operate. Firms perceive political instability, macroeconomic instability, high taxes, corruption, and access to finance as the most severe obstacles to growth and development (World Bank, 2008b). While another work states that access to finance, crime, and political instability are binding constraints on the growth of firms (Ayyagari, Demircug-Kunt, and Maksimovic, 2007). Managing these obstacles, while at the same time creating a business framework that promotes collaboration and competition, is the objective of government policy. Government policy relevant to economic development in general has been discussed extensively by the OECD, the World Bank, and other international organizations and is available on the Internet for further investigation of most countries and regions of the world (see World Bank, n.d; OECD, n.d.). Once a framework has been set up, regulations most relevant to innovation systems include legal protection for property, labour law, and trade policy, as well as science and technology policy that encourages, facilitates, and awards financing for projects. The following discussion of each of these topics illuminates their role in the overall innovation systems framework.

#### **Sectoral Standards**

The quality and production standards that are set by sector or international regulatory bodies and are not created or enforced by a national government. These sectoral constraints may have positive or negative effects on the market. While they can indicate a quality standard, they can also be used to eliminate competition. In technology-related products firms attempt to gain market share as rapidly as possible and therefore set the standard. For example, Microsoft Windows operating

system set a standard for software application developers, so that other hardware firms would adopt Microsoft's operating system or be eliminated from the market because of the lack of applications for their platform.

### **Entrepreneurship**

Regulatory issues concerning new business startups affect potential in bringing new technology or products to market and new processes into existence. In the Middle East and North Africa starting a new business requires eight procedures and takes up to twenty-three days to complete, while the equivalent for high-income OECD countries is five procedures and twelve days (Starting a Business, 2012). Minimum capital requirements and fees differ across countries. In the Middle East and North Africa 29.8% of income per capita is spent on capital and fees, while 4.5% of income per capita is spent on capital and fees in OECD countries (Starting a Business, 2012). Decreasing the number of procedures and making information concerning entrepreneurial support readily available would increase the likelihood that entrepreneurs could bring innovation to the market. Decreasing the number of procedures and days required for processing and providing startup funding would encourage and facilitate individual entrepreneurs to move from the invention to innovation stage of product development.

### **Trade Policy**

"Policies that promote trade and investment encourage business innovation because of external competitive pressures and knowledge transfers in terms of best business practices." (Aubert and Reiffers, 2003: 14). Imports of technologically sophisticated products expose countries to the latest in products and effect quality expectations of the local population. Firms benefit in learning about more efficient processes and gain the possibility of reverse engineering. The spillover effect occurs when those employed in firms benefiting from imported technology leave to start their own businesses or transfer to another company. While exports have not been proven to aid economic efficiency (Keller, 2004), it is an indicator of technological achievement.

### **Labour Law**

Labour market mobility relates not only to regulations concerning the topic but also transferability of skills to the most profitable sector within an economy. Restrictions on labour mobility and rules that constrain firms' ability to reallocate workers within the firm can be important barriers to adoption of new technologies (Parente and Prescott, 1994). For example, removal of regulations that result in involuntary overstaffing could increase labour productivity by 7% in India (World Bank, 2004). Restriction on firm entry and exit impede progress by propping up inefficient firms

and limiting expansion or creation of innovative firms (Liu and Tybout, 1996). Ensuring exit of unprofitable firms frees unemployed and underemployed capital and workers for more efficient use.

### **Intellectual Property Rights**

Intellectual Property Rights (IPRs) include patents for inventions, trade secrets, copyrights, trademarks, design rights, breeding rights for plant and animal varieties, and database rights (Granstrand, 2005). IPRs gained increasing importance during the last quarter of the twentieth century because of the development of knowledge intensive economies and increasing understanding that technology and innovation were key determinants of economic progress (Granstrand, 1999). As intellectual capital surpassed physical capital in importance for profit-seeking entities and international cooperation intensified, emphasis on intellectual property protection increased among policy makers and academics, particularly in the US. This was due to several factors, among them were pressure from US corporations and academics for protection and the government's concern that the US was losing its competitiveness to Asian economies that were reverse engineering American inventions (Granstrand, 2005).

Academic literature on IPs and patents offers diverse views on the affect of IPR on R&D. One perspective is that private firms will under invest in R&D if they are unable to obtain sufficient returns on their investments (Arrow, 1962). Patents, contracts, subsidies, and research consortia will help correct this. Another perspective is that firms and economies may over invest in R&D by duplicating efforts in attempts to be first to market or to beat the competition with a product, service, or process. Thus the social return may be less than the overall cost (Scherer, 1983; Romer, 1996). Other differences of opinion relate to the length of time and scope of the patent that should be awarded to the inventory. The length of time in patent evaluation depends on the nature of the competition and the trade off between dynamic and static efficiency, among other things (Nordhaus, 1969). Generally, the patent scope is negotiated between the applicant and patent examiner and complex to parameterize (Merges and Nelson, 1990).

Intellectual property protection and innovation are linked in the perspective that an inventor's invention may be copied, causing the lose of potential reward in the market. Research on patent systems, however, does not indicate that patents are required for a country's industrialization and economic development. While Japan industrialized within a patent system (Dutton, 1984), Germany, Switzerland, and Holland (Kaufer, 1971) industrialized without a patent system. An IPR system has not been necessary nor sufficient in developing technical and economic growth. Rather

the system has been found to be secondary and complementary to other factors that drive growth (North, 1981, Nelson, 1993). There is no indication that an international patent system will contribute to less-developed country growth (Granstrand, 2005). The determining elements that can be considered in the debate centre on the interaction of economic, technical and legal dynamics in a country, but more importantly, internationally.

### **Science, Technology, and Innovation Policy**

Objectives of a national science policy may include national prestige, and cultural values, national security, and economic objectives. Issues that must be addressed are similar to those faced by a firm: concern for allocating sufficient resources to science, distributing resources wisely, verifying that resources are used efficiently, and contributing to social welfare (Mowery and Sampat, 2005). Science policy affects universities, research institutions, technological institutes, and R&D labs and determines how these players are regulated and link to the overall environment. Instruments that can be used in policy include budgetary decisions on allocating funds to public research organizations, such as universities, and subsidies or tax relief. The fundamental question concerns whether the quality of scientific research, which determines its value in academia, necessarily leads to commercial value

Technology policy for NIS differs for catching-up countries and high-income countries. For the latter the focus is on producing the most recent technologies and applying them to further innovation, while for the former, catching up is the issue. Technology policy primarily affects universities, research institutions, technological institutions and R&D labs. The focus is on engineering within universities and links between universities and industry. Instruments that can be used include public procurement, trade policy, and economic incentives such as subsidies and tax incentives (Granstrand, 2005).

In terms of an innovation policy the debate concerns whether government policy should include most major policy fields and how policy can contribute to innovation. There are two perspectives. One perspective focuses on framework conditions. Basic research and general education are legitimate public activities, and intellectual property right protection is a legitimate field for government regulation. A second perspective emphasizes the links between components and because competence is unequally distributed among firms, emphasis should be placed on diffusion (Granstrand, 2005). One emphasizes initiatives aimed at promoting innovation within the institutional context, while the other aims at changing the institutional context in order to promote

innovation. The latter involves reform of universities, education, labour markets, capital markets, industry regulations, and competition laws. (Metcalf, 1995). Major objectives of innovation policy should be economic growth and international competitiveness within national boundaries. Changing the links among components to “level the playing field” among firms may not lead to international competitiveness. The extent to which policies mandate collaboration among firms rather than competition could affect a firm’s desire to innovate. The following discussion on links within innovations systems can help determine the most beneficial policy to meet the objectives of economic growth and international competitiveness.

### **2.7.3 Links**

The links within an NIS may be formal, such as an educational institution managing a federally funded research and development lab, or informal, such as membership in a professional organization or attendance at a conference held primarily to promote exchange of knowledge and ideas. Linkages can be facilitated by universities, cluster trade associations, informal alumni networks and other interactions that require sharing of knowledge for mutual benefit. The following categories may apply: competition which is the interactive process where actors are rivals, transactions in which goods and services are traded between actors, and networks, in which knowledge is transferred through collaboration, co-operation and long term network arrangements (OECD, 2001). Regardless of the links, scientific and technical innovations may spill over to other countries instead of being initially exploited by domestic industries.

In research on national innovative capacity it has been suggested that the strength of the relationship between the common innovation infrastructure and the industrial cluster, as defined by Porter’s diamond, is an important driver of the overall innovation capacity of a country (Furman et al., 2002). Not only are inter-firm relationships of critical importance, but the external linkages within the narrower professional science-technology system were also shown to be decisive for innovative success with radical innovations (Gibbons and Johnston, 1974). Research on diffusion revealed that the systemic aspects of innovation were increasingly influential in determining the rate of diffusion and the productivity gains associated with any particular diffusion process (see especially Carlsson et al., 2002). The strength of linkages determines the ability of the common innovative infrastructure to lead to innovation in the industrial cluster.

Porter’s (2000) diamond demonstrates the value of links in a National Innovation System. Porter defines a cluster as a geographically close grouping of interconnected companies and

associated institutions in an industry or field, linked by complementarities and commonalities. The geographic scope may range from a region, state, or single city to a group of neighbouring countries. Cluster boundaries are flexible because of changes in industrial sectors and technological and market developments. Regulatory changes also contribute to shifting boundaries, as they have in the telecommunications and transport sectors, for example. Clusters capture linkages, complementarities, and spillovers in technology, skills, and market needs that cut across industries and thus are broader than traditional industry categorizations. These externalities create a possible rationale for collective action and a role for government.

Porter (2000) discussed the potential advantage of cluster participation in that it offers customer knowledge, new technological process possibilities, access to talent within the proximity, and ongoing relationships with universities within the cluster. The ease of site visits and face-to-face contact promotes interaction that would not take place were cluster members remote from each other. Suppliers/partners get closely involved in the innovation process, so that the inputs they supply better meet the firm's requirements. Reinforcing other advantages for innovation is pressure from competition, peer firms, and comparison of firms in geographical proximity by outsiders. Firms must seek creative ways to distinguish themselves, which puts pressure on them to innovate or risk obsolescence. Cluster participation can retard innovation if a uniform approach to business and production develops and thus invalidates the creativity possible from the existing pool of talent, information, suppliers, and infrastructure.

## **2.8 Innovation Systems Methods of Analysis**

Conceptual foundations of innovation indicators have been based on the thinking of Nathan Rosenberg (1982), who questioned whatever research-based discovery was necessarily the preliminary phase of innovation, and he believed that innovation and diffusion processes were separable. Novelty was not only the completely new but also could refer to small-scale changes. Non-R&D inputs were important, and measurement had to reflect both aspects of innovation.

The OECD, in publishing the Innovation Manual or Oslo Manual (OECD, 1997), attempted to develop indicators to measure innovation. Ultimately, the process of measurement has led to expenditure measurements of inputs and sales measures of outputs to the innovation process. Current indicator classes include technometric indicators measuring technological performance characteristics, synthetic indicators for scoreboard purposes, and specific topic databases from



individuals and groups. Relevant to this investigation and measurement are the major established indicators used for innovation analysis: R&D data, data on patents, and bibliometric data.

### ***2.8.1 Research and Development Expenditure***

R&D has been the area for which the most comprehensive data has been collected. Documentation, such as that found in the Frascati Manual (OECD, 2002), precisely defines categories and activities included in R&D. “The basic criterion for distinguishing R&D from related activities is the presence in R&D of an appreciable element of novelty the resolution of scientific and/or technological uncertainty...” (OECD, 2002: 33). What is not included, for example, are education and training and industrial activities related to innovation, such as acquisition of products and licenses. The constraint of R&D data as an innovation indicator relates to its measuring only inputs. Attempts to match aggregate R&D to a measure of productivity across time and countries (Griffin et al., 2000) does not exploit the complexity of innovative activities nor the data available (Smith, 2000). There are also issues in attempts to use R&D data in determining R&D intensity, the ratio of R&D to a measure of output, such as sales or GDP. Because R&D does not include technology acquisitions, the R&D intensity may not accurately reflect low-tech industry innovation intensity (Hirsch-Kreinson et al., 2003).

### ***2.8.2 Patent Data***

The purpose of a patent system is to create an incentive for creating and sharing economically valuable knowledge by offering an inventor timed and limited protection over details of the new invention. While patent systems differ across countries, they should:

- Grant a patent for invention with commercial potential
- Record the details of invention
- Relate and link invention to relevant technologies and literature.
- Provide free access to data. (Smith, 2000)

Patents record inventions but do not indicate innovation as it is defined in NIS literature, which is novelty, brought to fruition. However, they can be used for observation and analysis of inventive activity, its relation to economic factors, and spillovers of knowledge among other facts (Jaffe, Henderson, and Trajtenberg, 1997; Macleod, 2000; Patel and Pavitt, 1997;).

### ***2.8.3 Recent Indicators***

Recent attempts to design better indicators offer a subject or object approach, depending on whether

the emphasis is on the actor or the output. The subject approach emphasizes the innovator and better captures small-scale incremental change. The OECD has attempted to determine internationally comparable data on innovation outputs with the Community Innovation Survey (CIS), based on their innovation manual, the Oslo Manual (OECD, 1997). The CIS, conducted in 1993 and 2002, covered 160,000 European firms and included the following: expenditures on activities related to new products, outputs from incremental and radical innovation and their sales, sources of innovation information, technological collaboration, and perception of obstacles and promoting factors of innovation. The survey concentrated on technologically changed products. Most processes are products of capital goods producing firms. This permitted a definition of change, an economic measurement in the form of sales across firms and industries, and a reasonable definition of novelty (Smith, 2000).

The object approach focuses on the objective output of the innovation process, of which measuring technical outputs is one (Archibugi and Pianta, 1996). Examples of this included the efforts of The Science Policy Research Unit at the University of Sussex, UK, in developing a database of information on technical innovations in British industry. The US Small Business Administration and other entities have gathered similar data by examining trade, engineering, and technology journals. One of the results of the object approach was Pavitt's (1984) identification of firm types as science based, scale intensive, specialized supplier, and supplier dominated. Categories were differentiated by sources of technology among other characteristics.

Identifying the importance of an innovation because it has been recognized in a publication is another output measurement. At the same time the bias introduced through this test of significance can limit the findings and only determine what is new to an industry and not the routine and more incremental activities of innovation.

In conclusion, it is apparent that academic and international organization literature falls into three categories:

- Descriptive overviews of national data, usually written by policy makers
- Analytical studies sponsored by the European Commission
- Econometric or statistical studies (Thuriaux et. al., 2001).

#### **2.8.4 Summary**

The systems of innovation approach arose out of the need to address how best to use increasing

technological innovation and new knowledge as a renewable factor of production. With an expanding knowledge base and the capabilities inherent in a networked world, how could the development of new knowledge and innovation be managed for the public good in economic terms? Given that economists determine outcomes through formulaic methods, how could it be demonstrated that a new system could lead to economic growth?

A systems of innovation perspective was proposed in that it could be built on evolutionary theory, use current innovation generators, and manage the system through government policies. The systems approach to innovation can be narrow, focusing on scientific research, or broad, focusing on learning, innovation, and competence building at different levels of aggregation. The broader perspective is more akin to a knowledge-based economy in that it includes innovation from all sources and may have a broader impact on science-based institutions and activities. The system has components and links between them. One category of components is actors, which are individuals, firms, educational institutions, research and development labs, and the government in its role as regulator and as a provider of funds for R&D. A second component is institutions, which are referred to in the innovation systems literature as “rules of the game”: the habits, norms, and laws that regulate interaction among groups and individuals. From this description, it becomes obvious that entities may be both categories and that sociocultural dimensions are an institutional component. Links within the system may include any means or vehicles through which actors and institutions interact and communicate for the development of knowledge.

Some conclusions from the attempts to measure innovation activity and outcomes include:

- Innovation occurs across all sectors of an economy
- R&D is not the most important innovation input
- Innovation inputs and outputs are distributed asymmetrically across sectors and countries
- Collaboration is widespread among innovating firms. (Smith, 2000)

For academic and policy-making bodies, the above list has now been proven through data gathering and statistical and econometric analysis.

What has not been widely referred to in academic literature on innovation systems, either because it has not been considered significant or because academics believe it lacks rigor and measurement, is business literature on innovation and managing change. This literature is more empirically grounded than artificially constructed systems. What seems to be lacking in academic literature are interviews and conversations with innovative organizations in diverse sectors of developed economies. A relevant study for future measurement and determination of innovation might include

how small and medium sized companies innovate and manage change.

## **2.9 Conclusion to the Theoretical Review**

Starting with Industrial Revolution I, technology increasingly played a role in economic growth, causing growth in new knowledge and innovation. Economic historians and other scholars have offered a variety of reasons of why this occurred and what characteristics it revealed about growth. This included Mokyr's belief that the epistemic base (know-what) of knowledge had broadened to support the generation of new knowledge and innovation based on this knowledge. Other contributing factors included the wider availability of knowledge through printing and a willingness to share knowledge through creative communities of scientists and others interested in knowledge.

Economists became dissatisfied with traditional growth theory that dealt with non-renewable factors of production and with the difficulty of determining the exact role of technology in the production function. Around the same time the discovery of the microprocessor expanded the options in new knowledge production and dissemination. While Solow (1956) offered a growth model that included technology as an exogenous force, it was left to Romer to show how knowledge, as a renewable resource, could affect other factors of production through technology as an endogenous force within the growth model. Technological innovation and the resulting new knowledge led to knowledge being recognized as a factor of production and the knowledge-based economy. Although an exact start date for use of the knowledge-based economy label has not been determined, Machlup and Drucker used the term in the 1960s.

It was found that the increased base of the knowledge and new technological capabilities in ICT, that made knowledge widely available, expanded the opportunities for innovation. With the growth of firms and other entities with resources to conduct and support the innovation process, as well as the development of measurement capabilities, innovation was recognized as a significant force in economic progress. The innovation process needed to be further investigated and managed by firms and governments at a national level. It was understood that generators of innovation were not only the R&D of traditional thinking, but also the market, in interaction with customers, competitive forces, suppliers, and other forces, and production, meaning within firm activities performed by a firm's work force. As a response to the role of innovation in economic growth and a recognition that interaction and interactive learning were part of the innovation process, a systems approach was proposed by scholars and policy makers. This approach requires components: institutions or

rules of the game, such as laws and social norms of behaviour, and organizations or actors, such as firms, that create innovation. The links between these components are crucial to its functioning in sharing new knowledge and technology, which increase both the epistemic base and possibilities of growth in prescriptive knowledge. A dilemma lies in what can be termed the cohesion-competitiveness dichotomy (Chorafakis and Pontikakis, 2011). If a firm's core competency is built on innovation within that core competency, what is the impetus for the firm to share its technology for the common good in the short term if its existence depends on making a profit to survive? This is the challenge for government policy.

Theoretically, the National Innovation Systems framework is akin to evolutionary theory. It defines the scope of analysis at the level of the state and focuses on the role of national institutions that support and promote networking, learning, and innovation. Methodologically, the approach emphasizes qualitative differences in various innovation systems rather than providing quantitative evidence. More recent studies have attempted to make up for this lack with quantitative studies, such as Furman and others (2002), Furman and Hayes (2004), and Balzat and Pyka (2006). The current research intends to add to the quantitative body of work. It examines factors of a cultural nature, called sociocultural dimensions, that help drive innovation in a knowledge-based economy. In innovation systems these are considered informal institutions, or rules of the game, that influence economic and social behaviour and help determine formal institutions that set policy.

## **Chapter 3 Sociocultural Environment for Innovation**

### 3.1 Introduction to the Sociocultural Environment

National systems of innovation are primarily defined in terms of determinants influencing innovation processes, yet researchers use different approaches to its study and focus on different determinants (Lundvall, 1992; Nelson, 1993). While Nelson focused more narrowly on national R&D systems, Lundvall agreed with Freeman in recognizing that organizations that support R&D are grounded in a wider socio-economic system in which cultural and political influences help to define scale, direction, and success (Freeman 1995). Generally, systems of innovation include “all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion, and use of innovations” (Edquist, 2005: 183).

Section II seeks to discover the cultural context that contributes to innovation within an economy. Although various strands of literature discuss culture in its relationship to economic development, economists largely assign cultural factors a secondary or non-existent role in their models that determine economic growth. Thus a definitive list of sociocultural dimensions that contribute to national innovative capacity is lacking.

The notion of cultural factors means different things to different academic disciplines and within those disciplines, to different academics. Therefore, the current study attempts to synthesize the findings from diverse strands of literature to define a list of sociocultural dimensions that will be tested to discover their significance in innovation systems. The exploration draws on two primary areas of research: cultural characteristics associated with societies as they transitioned to a knowledge-based economy and cultural characteristics associated with innovation.

The discussion starts with the concept of sociocultural dimensions then proceeds to examining economies as they transition to a knowledge-based economy. This is followed by an assessment of literature on innovation and a case study of an emerging innovator country, Finland (Furman et al., 2002). Finland developed a national innovation system, and Dalman and his colleagues (2006) attributed part of Finland’s success to sociocultural dimensions. A case study has several uses as a research tool. It can be analogous to a single experiment and can provide a critical test of theory or corroborate, challenge, or extend theory. A second use, as in clinical psychology, can be as an extreme or unique case. The third use occurs in a situation where some phenomenon has not been studied before, a revelatory case (Yin, 1989). The intent here is to use the Finnish example to corroborate and extend theory that sociocultural dimensions contribute to innovation systems. The

case can also provide clues to sociocultural dimensions that may be relevant to innovation systems. The chapter ends with an identification of the gap in the literature, the research questions, and a list of sociocultural dimensions and hypotheses to be tested.

## **3.2 The Concept of Sociocultural Dimensions**

### ***3.2.1 Historical Perspective***

Historically, culture was primarily based on religion and changed very slowly. In many religions, social status was hereditary and social mobility and individual economic accumulation were discouraged (Fukuyama, 1995). With industrialization and modernization, societal views became more secular and open to change within the Western world (Granato, Ingelhart, and Leblang, 1996). An emphasis on economic accumulation and the possibility for social mobility were the result. Weber (1905 [2001]) argued that the Protestant Reformation taught the pursuit of wealth as not only an advantage but also a duty. This provided the moral fortitude for those without social status to challenge the previous order and create a new one based on wage earners for the purpose of economic profit. Marx (1859 [1979]) viewed culture as determined by the economic development and economic interests of social classes. In terms of causality, modernization theorists claimed economic development changed cultural values (Ingelhart and Baker, 2000; Marx, 1976), while another group of researchers avowed that cultural values foster economic growth (Landes, 1999; Weber, 1905 [2001]). A third perspective was that economic development and cultural values co-vary (Ingelhart, 1990).

### ***3.2.2 Definitions of Culture***

Guiso, Sapienza, and Zingales (2006: 23) defined culture “as those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation.” This narrow definition focuses on dimensions that can impact economic outcome rather than factors that may have been caused by economic events. Gorodnechenko and Roland (2010) defined culture as the set of values and beliefs people had about how the world, both nature and society, worked, as well as the norms of behaviour derived from that set of values. Thus culture affects not only social norms but also economic behaviour. Cultural values represent shared abstract ideas about what is good, right, and desirable, and influence an individual’s behaviour within the society. These values influence social organization and lead to diverse social patterns of economic interaction (Bangwayo-Skeete, et al., 2009).



Culture is considered to be an institution, in that it imposes constraints on individual behaviour (North, 1990), and at the same time it is evolutionary in that it is dynamic and changes over time (White, 1959). As an institution culture tends to be slower moving than political or legal institutions and therefore has an important effect on the choice of political and legal institutions themselves and their functioning (Gorodnechenko and Roland, 2010). Economists are in broad agreement that institutions, culture included, are an important factor moulding and involved in economic growth, but offer diverse analyses. Institutions have been associated with social technologies, corresponding to Veblen's (1899 [2005]) widespread habits of action. In the evolutionary sense there are two strands of thought. One emphasizes that social systems are determined by technological systems (White, 1959), while the other focuses on a Darwinian approach, arguing that all societies adapt to their environment in some way (Steward, 1955 [1979]). Cultural mores continue to be followed so long as they satisfy members of a society. When these standards of behaviour no longer satisfy a society, culture evolves to meet the changing needs and new behaviours and values become instilled.

This research takes the broader view of culture that incorporates values and beliefs and the resulting social interaction that affects economic behaviour and outcome. It also subscribes to the concept that culture evolves over time to meet the changing needs of society, although the change lags society's needs. The rationale for the use of sociocultural rather than cultural is precisely for this reason. It incorporates the values, beliefs, and norms of behaviour, the resulting social interactions and how these evolve into new social interactions, which affect economic behaviour. Within the context of National Innovation Systems, sociocultural dimensions are informal institutions that are a part of the environment in which innovation takes place.

### **3.3 Transformation to a Knowledge-based Economy**

Lundvall claimed that the knowledge-based economy would have a certain number of characteristics, including:

- Innovation is a permanent feature.
- It is an economy of networks at different hierarchical levels.
- It is accompanied by new forms of organizations involving industrial cooperation, polarization, and relations between the public and private sectors.
- Human capital plays a decisive role and the capacity to learn matters more than the level of knowledge.
- Information-related activities proliferate in all sectors of the economy.
- It challenges traditional economic theory (Lundvall from Aubert and Reiffers, 2003: 9)

The defining factor in a country's transition to a knowledge-based economy, however, was the new technological paradigm resulting from ICT. This enabled new knowledge development, processing, and communication to occur at a speed and volume not possible previously and led to innovation and new knowledge creation being the primary determinants of economic growth. The effects of technology were pervasive; and the new paradigm facilitated economic and social relationships (Dosi, 1988; Kuhn, 1962). Economically, productivity depended on economic agents' ability to generate, process and apply knowledge through the new ICT capabilities. Socially, the information technology revolution was affected by the ideals of the 1960s and 1970s in freedom of expression, personal autonomy, and challenges to the establishment (Castells, 2010).

In addition to ICT capabilities, other distinctive characteristics of the knowledge-based economy were informational, global, and networked (Castells, 2010). Firstly, the economy was informational in that the productivity of economic agents depended on their ability to generate, process, and apply knowledge efficiently. Secondly, it was global in that core activities of production, consumption, and distribution and their components were organized on a global scale through a network of economic agents. Finally, it was networked in that productivity and competition played out in a global arena of interactions among business networks. This integrated economy led to greater productivity and efficiency and development of new organizational and institutional forms (Dosi, 1988; Machlup, 1980). Each of these characteristics, ICT and new technology, knowledge as a factor of production, networks and globalization, and new institutional forms, will be investigated to determine sociocultural dimensions that would be required for successful transition to the new paradigm.

### ***3.3.1 ICT and New Technology***

Empirical analysis of technology development in the U.S.' Silicon Valley reveals that the synergy to generate new commercially significant knowledge was a contributing factor to firms' success. The emergence of new technology in the Valley was a key driver in developing the new technological paradigm (Saxenian, 1994). Saxenian determined that the Silicon Valley phenomena occurred with the founding of Hewlett Packard in 1939 by two Stanford University students, through the encouragement of Stanford professor and later provost, Terman. Terman also supported Shockley, who invented the transistor. This invention eventually led to the founding of Fairchild Semiconductors, which was founded by eight engineers who had worked for Shockley and recognized the potential of using silicon for integrated transistors (Castells, 2004). These engineers spun-off their own businesses to further develop new technology and gain financial rewards. Intel

engineers eventually developed the microprocessor, which Wozniak and Jobs then used to create the personal computer for Apple in 1976 (Linzmayr, 2011).

Each new discovery made the next generation of technology possible. The microprocessor led to microcomputers; telecommunications made networks and ICT power possible; software made microcomputers usable; and networking and software made the web possible. Innovations resulted from a convergence of skilled scientists, funding from the U.S. Department of Defense (DOD), Stanford's institutional leadership and world-class status, and eventually a network of venture capitalists (Saxenian, 1994). Much like the trajectory of technological development, major invention was followed by a series of innovations.

The critical ingredient in technology development was creating this synergy of actors, individuals, universities, and firms on the basis of knowledge related to commercial applications. As soon as knowledge was available, the dynamism of the social and industrial organization of companies was crucial in fostering or stymieing innovation (Saxenian, 1996). The environment required the geographic concentration of research centres, higher-education institutions, advanced-technology companies, a network of suppliers of goods and services, and networks of venture capital to finance start-ups (Castells, 2010). Once consolidated, the environment generated its own dynamics and tended to attract knowledge, investment, and talent from the global market. The surrounding areas, because of their proximity to and understanding of technological innovation, were well positioned to take advantage of new developments. The one difference that Castells and Hall (1994) identified in countries outside the US was the absence of the entrepreneurial role. In Europe, the old metropolitan areas of the industrialized world were the centres of innovation. However, the key ingredient remained the ability to generate synergy on the basis of knowledge and information directly related to commercial applications.

Newly industrializing countries face a different issue than developed economies faced in the 1960s and 1970s. Generally, acquiring new technology through international channels was the most efficient vehicle for technology upgrading because innovation could be costly, risky, and path-dependent. However, if foreign technologies were easy to diffuse and adopt, a technologically backward country could catch up quickly (Barro and Sala-i-Martin, 1995; Eaton and Kortum, 1995; Grossman, 1994; Romer, 1994), but this has not been the case. One view is that technology diffusion and adoption relies on substantial and well-directed tech effort (Lall, 2001, 2005) and absorptive capacity (Cohen and Levinthal, 1989; Girma, 2005), as well as a minimum level of

human capital (Eaton and Kortum, 1995, Xu, 2000). While codified knowledge is available through the education systems, in databases, and other sources, a large amount of technological knowledge is tacit and these spillovers are geographically bounded (Jaffe et al., 1993). As a result, international knowledge and technology transfer may not help develop the tacit knowledge required for effective absorption. Another consideration is that technical change may be biased in a particular direction and not be appropriate to economic and social conditions of developing countries (Acemoglu, 2002; Atkinson and Stiglitz, 1969; Basu and Weil, 1998).

Evidence indicates that the opportunity for interaction with international entities offers benefits for technology diffusion if it is accompanied by indigenous creative efforts (Fu et al., 2011) and the presence of supporting institutional, government, and innovation systems (Sasidharan and Kathuria, 2011). For example, MNEs adopt more integrated innovative practices if the local economy attempts to develop its own innovation capacity (Franco et al., 2011). Therefore, encouraging indigenous R&D and innovation activities are indispensable for adaptation of foreign technology and its diffusion and capability building. The decision of how best to gain access to new technology is country dependent and based on sociocultural factors of the country, as well as the country's supporting institutional and governance structures.

One may conclude that an outward-oriented society would have a performance advantage over an inward-oriented society in exposure to new technology and new ideas and their possibilities. Without a certain level of human capital that can evaluate and adapt technology, as well as create indigenous innovation, foreign technology may simply become part of the static technology base. Thus, an evaluative capability is required on the part of local populations to determine what and how to adopt as well as a certain know-how or tacit knowledge to use the technology (Nelson and Phelps, 1966).

### ***3.3.2 Knowledge as the Primary Factor of Production***

Knowledge as the primary resource meant that the acquisition of information and its application become the foundation of productivity (Drucker, 1964 [1986]). Knowledge became valuable if and when it could be applied: the imagination and skill of the applier provided the added value (Drucker, 1964 [1986]). This, combined with networking capabilities and globalization, created a fundamental shift in the structure of employment, in work processes, in the life of workers, in how firms competed in the market place, and in the balance of power within society and the firm.

The firm's labour force was restructured to include a core labour force, made up of information-based management and analysts (Reich, 1991), and a disposable labour force that could be added to a firm's labour force through subcontracting, outsourcing, part-time, and contract employment (Castells, 2010). This was facilitated through the network and ICT capabilities to add or reassign workers and projects and facilitate communication within an organization. Flexible employment meant that the relationship between worker and employer changed and allowed rapid change in employment contracts with little penalty. It also included non-standard employment relationships, such as outsourcing, part-time, seasonal, and temporary assignments. Job tenures were shortened and a long term relationship was not assumed, even with a contract (Rousseau, 1995). Employment relationships were often mediated by forces external to the firm, such as the market or other pressures. Flexibility in work included rapid changes in the quantity of work required, rapid changes in skill requirements, and reflexivity in work tasks (Benner and Tushman, 2003). Whereas previously experience was rewarded, now the value of a high tech engineer and manager with extensive experience declined (Benner and Tushman, 2003).

Information technology became the critical ingredient of the work process because it provided the infrastructure and possibility for feedback and determined innovation (Castells, 2010). This transformed the work process in several ways. Value added was mainly generated by innovation in hardware, software, financial products, and similar sectors. Innovation was dependent on research potential and specification capability. Task execution was more efficient in that optimum worker/machine interaction could be automated and human capital could be used for adaptation. Internal adaptability and external flexibility were fundamental in organizations.

Performance in high-performance work organizations was based on three factors: the high level of skills of an experienced labour force, increased worker autonomy, and worker's involvement in upgraded processes (Shaiken, 1994). The value added by the worker in applying knowledge shifted the emphasis in productivity from the assembly line to the worker (Drucker, 1964 [1986]). Knowledge workers expected to be engaged in complex problem solving that required judgment and a high level of education. They expected challenging work, good pay, and competent management (Florida, 2002). At the same time as the growth in knowledge-workers, low-end, unskilled service occupations increased and caused increased polarization of social structures (Bluestone and Harrison, 1982; Tsang et al., 1991). Reflexivity in work tasks (Lash and Urry, 1994) required continuous improvement and focus on how to improve to meet rapidly changing market.

Business strategy and competition in the market place changed as a result of knowledge as the primary resource. In a knowledge industry, such as software, the upfront costs are high, but unit cost diminishes the more produced, while material product-based industries face rising production costs as firms encounter scarcity (Kurtzman, 1997). This difference between diminishing-returns industries, natural resources, and increasing-returns industries, software, changed the dynamics of competition and business strategy. Under conditions of increasing returns, competition was driven by firms trying to capture market share as quickly as possible and by being the first-to-market with a product and then selling more to the same customer base, a strategy followed by Amazon. With natural resources such as oil, firms operated under conditions of increasing costs and diminishing returns (Kurtzman, 1997). A firm produced a set amount of barrels per month but could not easily triple production, either because of production capacity or because supply would quickly be depleted. There was a limit on how fast the resource could be exploited.

Conserving resources was an objective of the old economy whereas expanding as quickly as possible to gain market share was a part of the new dynamic. New firms enter and compete by selling something that is new and/or better rather than providing the same product at lower cost (Lazonick, 2005). Alternatively, firms formed strategic partnerships to gain mutual benefit and monopolize the market. Microsoft and Intel formed an alliance to use this expansion strategy with IBM. when IBM. decided to produce a PC. Their alliance to put Intel chips and MS Windows operating system in PCs gave them an edge in attracting software developers to write applications for the Intel-Windows alliance, which resulted in other PC manufacturers to adopt the same Wintel strategy.

Another aspect of knowledge as the central resource was the role it played as an attribute of power. In traditional societies information was an attribute of power and shared reluctantly (Aubert and Reiffers, 2003). With knowledge dissemination required in a knowledge-based economy, knowledge could no longer act as the central power base.

Knowledge as a factor of production could transform work only if participants were willing to share information and had the vehicle or links to do so. Technology provided the latter, and a shift in attitude towards sharing knowledge occurred through the recognition of gaining mutual benefit or simply because information was more widely available. Given changes in the market place and resulting business strategy, out-pacing competition in the rapidly changing market required connection with the outside world. The pace of change also required adaptability on the part of

firms and workers to transfer know-how to new paradigms.

### **3.3.3 Networks and Globalization**

Networks were not only the result of ICT but also the result of social movements of the 1960s and 70s and of changes related to requirements for productivity growth in an economy where knowledge was the primary resource (Castells and Kiselyova, 2003). While social movements and institutional policies played a role in this restructuring, ICT provided the crucial digital networking capabilities that made possible the shift to a networked society and changed the interaction among economic and social agents.

Previously, vertical organizations dominated because organizations could not master or manage resources needed to fulfill a project larger than a certain size and complexity. As a result, large corporations decentralized into networks of semi-autonomous units and engaged in inter-organizational collaboration to complete projects (Powell and Grodal, 2005). Small and medium-sized firms also formed networks to keep their autonomy and flexibility and yet create the capability to bring together resources for larger projects and become providers for large corporations.

From a social perspective, digital networks expanded the domain of private social interaction and created the modern society of networked individuals. This provided an open forum for discussion of political opinion and behaviour, allowing opinions and behaviours to be formed in the space of communication (Castells, 2010). While creating the opportunity to practice open communication and to access information previously unavailable, social networking did not necessarily create truth in information since accuracy verification was the responsibility of the communicator and receiver. Social networking capabilities introduced transparency in communication and offered the possibility of developing evaluative competency to those who had not had the responsibility previously.

Core activities that shaped and controlled human life were organized in global networks: financial markets, production, management and distribution, skilled labour, science and technology, international institutions managing the global economy and intergovernmental relations, and other activities (Castells, 2000; Held, 1999; Juris, 2004; Stiglitz, 2002).

Globalization is a more contested concept than networking (Held, 1999). Held and his colleagues

offered three perspectives on globalization: the Hyperglobalist, the Skeptical, and the Transformationalist. The first perspective saw globalization as a new era characterized by declining importance and authority of the nation-state, brought about through economic functioning of a global market. The Skeptical perspective views international processes as more regionalized than globalized. Skepticals argue that global governance structures and market are a version of neo-liberal economic strategies from the West. The transformationalist perspective sees no single cause for globalization-economic or otherwise-and the outcome of globalization process has not been determined (Held, 1999). According to a world systems theory, globalization refers to a global socio-historical order and the socio-political economy of that order. More recently, globalization focuses on cultural and intellectual processes as an increasingly cosmopolitan activity (Stehr, 2002). In the current discussion, globalization refers to the economy as global in that core activities of production, consumption, and distribution and their components are organized on a global scale. This economy is networked because productivity is generated through and competition played out in a global network of interactions among business networks (Castells, 2010).

The global economy was differentiated from a world economy in its capacity to work as a unit in real time because the core components had the institutional, organizational and technological capabilities to do so (Castells, 2010). This resulted in interdependency of capital markets and currencies, as well as monetary policies and interest rates (Held, 1999). Trade changed because the knowledge component of goods and services became the decisive factor in value added, diversification of production, and formation of trade relations (Held, 1999; Hockman and Kostecki, 1995; Krugman, 1995).

The networked society manifests itself in many different forms, according to the culture, institutions, and historical trajectory of each society. However, the networking capability, which created the possibility of global business, particularly for SMEs, required openness in communication to conduct business, given that entities were often geographically separated. Sharing knowledge across networks in pursuit of innovation could not occur without this openness. Socio-cultural factors associated with globalization and networked knowledge-based economy also include adaptability to a changing work environment and an openness to outside influences in learning to communicate effectively across cultures. At the same time the networked society introduced responsibility in disseminating and evaluating information and new knowledge, which requires a sense of ethics and ethical thinking in differentiating facts from manipulation of facts.



### **3.3.4 New Institutional Forms**

Drucker (1968 [1986]) forecasted pluralism in institutions and a diffusion of power among them. If value within a society was decided by the dominant institutions (Castells, 2010), then in a networked society, value was multidimensional and defined differently by different networks. The networked society required a change in institutions, not only in structure but also in how they interrelated and functioned.

Previously, institutions were large, had well-defined boundaries within a hierarchy relative to each other, and performed certain functions. Each member of the system understood the positions of each within the hierarchy and their functions (Castells, 2010). The new institutional form was a direct result of networking capabilities introduced through technology and the resulting global community. Because of rapid changes in technology and more readily available new knowledge, the concentration of power was dispersed. Organizations became flexible and interdependent, and did not have inferior or superior status relative to each other. Lundvall (1996) claimed the new forms of organization would involve industrial cooperation and sharing knowledge and technology among actors within the system. The fundamental goal of firms was to cope with uncertainty caused by pace of change in the economic, institutional, and technological environment of the firm and enhance flexibility in production, management, and marketing. Mass production systems and equipment became too costly. The solution came in the form of high value production and reprogrammable production systems, such as flexible specialization (Piore and Sable, 1984) and high-volume flexible production systems (Cohen and Zysman, 1987).

Another aspect of institutional structure was the predicted demise of large corporations and multinationals in favor of small and medium-size businesses (SMEs) to meet the need for flexibility (Harrison, 1994). While the demise did not occur, there was a change in the traditional corporate model of organization based on vertical integration, hierarchical, functional management, and the technical and social division of labour. SMEs were better adapted to the flexible production system required in knowledge-based economy, and large entities required new management methods, multifunctional labour, new labour processes, and total quality management, to meet the need of the new paradigm (Harrison, 1994; Sengenberger and Campbell 1992). Knowledge management and information processing became essential to organizational performance.

Fukuyama (2005) spoke of a proclivity for spontaneous sociability as a cultural trait, a capability for forming new groups or associations with others, as a factor in the ability to innovate

organizationally. While Fukuyama attributed the modern corporation of the US and Japan to this spontaneous sociability, it seems more applicable and useful in an economy where rapid change and adaptability dictates market success. Although it does not create an advantage in capital intensive and highly complex manufacturing processes, the capability for forming new groups and associations allows the flexibility to create new associations and the flexibility to down size or shift production when situations demand. Adaptability is also required to work in a new institutional configuration and to shift out of power based work to a more egalitarian approach.

### **3.3.5 Summary**

The outcome of the capabilities of ICT, the concept of knowledge as the primary factor of production, and the networked, global society with the resulting new institutional requirements, placed the networking capacity of institutions, organizations, and social actors at the centre of productivity. Knowledge management and information processing became essential to the performance of organizations (Harrison, 1994; Sengenberger and Campbell, 1992; Storper and Harrison, 1994; Williamson, 1985). Access to the global store of new knowledge was a key to innovative capacity.

While employment in advanced countries increased in services, manufacturing did not disappear as had been predicted. Services depend on linkages to manufacturing, and manufacturing activity is critical to productivity and competitiveness of the economy (Cohen and Zysman, 1987). Global manufacturing continued growing through 1990, although it declined in the developed world. Analysing the evolution of employment in G-7 countries during the 1970-1990 period revealed a pattern of shifting away from manufacturing jobs, coupled with expansion in producer services, social services, and other services. However, G-7 countries differed in the pace of the shift, depending on cultural, social, and political agendas (Castells, 2010). Countries that maintained the most efficient links between manufacturing and services (Japan and Germany) seemed to be at the forefront of economic and social stability.

Sociocultural dimensions that were highlighted in successful transition to a knowledge-base economy were openness to outside influences to gain access to new technology and knowledge, transparency in communication to operate globally and collaborate in R&D and share innovation, and adaptability to changing work conditions and transference of skills to new paradigms. Spontaneous sociability (Fukuyama, 1995), the capability to form new groups and associations with others, improved the ability to innovate organizationally.

### 3.4 Literature on Innovation

Literature on innovation in firms, research labs, and universities provides another source of cultural characteristics associated with innovation. Negroponte (2003: 1), co-founder and chairman of the Massachusetts Institute of Technology Media Laboratory (MIT), recognized that innovation was “undisciplined, contrarian, and iconoclastic; and...nourishes itself with confusion and contradiction.” He asked the question “what makes innovation happen, and just where do new ideas come from?” Providing a good education system, encouraging different viewpoints, and fostering collaboration are only part of the answer. Negroponte (2003:2) provided an enlightening opinion on the stimulation of creativity:

Our biggest challenge in stimulating a creative culture is finding ways to encourage multiple points of view. Many engineering deadlocks have been broken by people who are not engineers at all...Perspective is more important than IQ. The irony is that perspective does not get kids into college...Academia rewards depth. Expertise is bred by experts who work with their own kind. Graduate degrees, not to mention tenure, depend upon tunnelling into truths and illuminating ideas in narrow areas. The antidote to such cannibalization and compartmentalization is being interdisciplinary. Interdisciplinary labs and projects emerged in the 1960s to address big problems spanning the frontiers of physical and social sciences, engineering and the arts. The idea was to unite complementary bodies of knowledge to address issues that transcended any one skill set...Only recently, however, have people realized that interdisciplinary environments also stimulate creativity. In maximizing the differences in background, cultures, ages, and the like, we increase the likelihood that results will not be what we had imagined.

While skills that lead to innovation are not necessarily culturally bound and can be found in virtually every society, the mobilization of these skill is thought to be culturally determined (Herbig and Dunphy, 1998). The discussion, therefore, seeks to determine the sociocultural dimensions that lead to innovation and mobilize the skills to create outcome. Attributes associated with Negroponte’s observations are examined from the perspective of academic works, as well as populist business management guides, to provide a well-rounded view of characteristics that drive innovation.

#### 3.4.1 Cognitive Diversity

Dahlman et al. (2006) found that the Finnish spirit of cohesiveness and emphasis on equality contributed to developing an innovative economy and attributed these traits partially to Finland’s historical geographic isolation, homogeneous gene pool, and unique language. Negroponte (2003)

found that a harmonious and homogeneous society was unlikely to catalyse idiosyncratic thinking, while a heterogeneous culture breeds innovation by virtue of its people, who look at everything from different viewpoints. Florida (2002: 249) believed that a geographic place could provide the environment for creativity, and the place could be identified by the “3 Ts of economic development: Talent, Tolerance, and Technology.”

The question becomes what is meant by diversity in the context of supporting creativity and innovation. Page (2008:7) answers this question and frames cognitive diversity as a toolbox with four tools, which he defined as follows:

- Diverse Perspectives: ways of representing situations and problems. People see the set of possibilities differently.
- Diverse Interpretations: ways of categorizing or partitioning perspectives. This refers to categories people use to classify events, outcomes, and situations.
- Diverse Heuristics: ways of generating solutions to problems. Solutions range in sophistication from simple rules of thumb to sophisticated analytic techniques.
- Diverse Predictive Models: ways of inferring cause and effect. This describes causal relationships between objects or events.

Page found that diversity trumped homogeneity in thinking in that collections of people with diverse perspectives and heuristics outperformed collections of people who relied on homogeneous perspectives and heuristics. He made a conditional claim that diversity trumped ability in that random collections of intelligent problem solvers could outperform collections of the best individual problem solvers. Diverse values, or preference diversity, however, can create conflict, which is one reason management books stress agreeing on a common goal in project or teamwork (Mannix and Neale 2006).

Research suggests that diverse perspectives and tools enable collections of people to find more and better solutions and contribute to overall productivity (Thomas and Ely, 1996). Diverse predictive models enable crowds of people to predict values accurately (Surowiecki, 2004), while diverse fundamental preferences frustrate the process of making choices (Williams and O'Reilly, 1998).

Page investigated the causes of this diversity and determined that there were two direct causes, training and experiences, and one indirect one, identities. People trained differently, such as a doctor and an architect, acquire different cognitive tools-different perspectives, interpretations, and

heuristics. Formal education offers fundamental knowledge of basic physics, literature, mathematics, and history, but also perspectives and heuristics. Other types of training provide us with different ways of seeing the world and understanding causality. These influence our interpretations.

Experiences lead to development of diverse toolsets in order to succeed. A person living by the ocean quite likely knows how to swim and understands tides better than a person living in a desert. The latter would therefore be more likely to be caught in rising tides than the ocean side dweller. A person who has cracked the glass on their iPhone is more likely to consider the durability of a phone the next time they purchase one. Creative thinking relies on analogies, which implies a central role for experiential diversity in creating cognitive diversity (Page, 2008).

Culture is part of identity, and human beings hold onto their cultural traits as long as we they are connected with people who share them. Ethnic origin and race, for example, shape our experiences and therefore create tool differences. Most people react to women and men differently, yet this does not imply that they differ in the perspectives, heuristics, interpretations, and predictive models that they could acquire (Page, 2008).

Page also found that serendipity plays a role in creative thinking. Apple's founder, Steve Jobs, studied calligraphy courses in college, and the experience taught him to care about fonts (Issacson, 2010), which helped Apple cater to a creative niche like advertising that needed font beauty and variation. While breakthroughs require serendipity, the serendipity arises from diverse preparedness, as in the case of Jobs.

For organizations in rapidly developing fields, heterogeneity in the portfolio of collaborators allows firms to learn from a wide stock of knowledge. Organizations with broader networks are exposed to more experiences, different competencies, and added opportunities (Beckman and Haunschild, 2002). "Innovation occurs at the boundaries between mindsets, not within the provincial territory of one knowledge and skill base" (Leonard-Barton, 1995: 62).

### **3.4.2 Risk Tolerance**

The entrepreneur, or innovator in innovation systems terminology, has been defined as the firm or individual that provides the resources to turn invention into innovation (Fagerberg, 2005).

Research has also suggested that the level of innovation within a society is directly proportional to

the status and encouragement assigned to entrepreneurial efforts within the society and to the role it plays in the survival of the culture (Herbig and Dunphy, 1985). Early definitions of entrepreneurship centred on the willingness of entrepreneurs to engage in calculated business-related risks (Brockhaus, 1980), and this view of entrepreneurs as risk takers has continued to gain support throughout the twentieth century. As McClelland (1987) emphasized, theorists agree that entrepreneurship, by definition, involves taking risks. In fact, Negroponte (2003) attributed U.S. success in innovation partially to the fact that the U.S. does not stigmatize failure. He found that many venture capitalists were more likely to invest in someone who had failed with a startup than someone who was launching a startup for the first time. Ultimately, risk taking in starting a new business and creating new technology played a pivotal role in the innovative capacity of the Silicon Valley.

### ***3.4.3 Openness to Outside Influences***

Dahlman et al. (2006) found that sociocultural dimensions of the Finns, in addition to government policy and other factors, contributed to developing innovative capacity. The Finns' curiosity about the outside world created an openness to outside ideas and technology which led them to experiment with and develop their own versions of telephone technologies almost as soon as they were invented. This openness to new ideas and solutions has been found to be essential for innovation projects because of the fundamental characteristics of innovation: every new innovation consists of new combination of existing ideas, capabilities, or resources and the greater variety within a system, the greater the possibilities (Fagerberg, 2005). Evolutionary logic offers the example of Eurasian landmasses, which were more innovative than small isolated populations elsewhere because of their exposure to new ideas (Diamond, 1998).

The value of openness to outside influences takes place not only between national entities to keep up with new global knowledge but within national boundaries as well. The more firms interact with external sources, the greater their innovativeness and the more pressure placed on others to follow suit to compete in the local and global markets. As Fagerberg (2005) found the organizational structure and knowledge base co-evolve within a firm, and while beneficial for day-to-day operations, this may diminish the firm's capacity for absorbing new knowledge created elsewhere (Fagerberg, 2005). The growing complexity of knowledge bases necessary for innovation means large firms depend on external sources for innovative activity (Narula and Zanfei, 2003, Powell and Grodal, 2005).

### **3.4.4 Openness in Communication**

At the digital bubble's peak in the U.S., being open about ideas was particularly hard for computer scientists because people saw wealth as coming from not sharing ideas. According to Negroponte (2003), MIT students would withhold ideas until after graduation at which point they would enter the workforce and gain significant value from their own ideas. As a result, many research labs declined in effectiveness (Negroponte, 2003).

In contrast, the work of Bell Labs provides a positive example of the value of knowledge sharing. The Labs conducted so much research that it easily housed high-risk programs, including blue-sky thinking that led to information theory and the discovery of the cosmic microwave background radiation. While AT&T benefited sometimes, the world gained much (Gertner, 2012).

Knowledge transfer is central to the innovation process, and it takes two forms. It occurs when one firm produces a component well, and the second firm excels at using the components for a finished product. A second form occurs when existing information may be recombined in a novel way (Rosenberg, 1976). Both forms require successful exchange of ideas (Rosenberg, 1976). While explicit or codified knowledge is easily transferred, tacit knowledge requires trial and error to apply in different settings. As communication and understanding develop, complex tacit knowledge can more easily be communicated, and subtle forms of information can be more effectively conveyed (Lundvall and Ernst, 1996).

Networks, as communication vehicles, contribute to innovative capabilities of firms by exposing them to novel sources of ideas, enabling fast access to resources. Networks make it easier to transfer tacit knowledge in the form of finished inputs, while networks involved in the co-creation of novel ideas may succeed or fail on the basis of their ability to convey and transfer ideas that are not easily codified (Powell and Grodal, 2005). The challenge of networks is developing capacity to simultaneously enhance the flow of information among current participants and be open to new entrants.

## **3.5 Other Dimensions**

Two other attributes of culture have been widely discussed in literature on economics and sociology (see authors mentioned below) as contributing to economic development and must be included in this discussion. They include *social capital* and *trust*.

### **3.5.1 Social Capital**

One of the initial links established by sociologists and political scientists between culture and economic behaviour was through social capital (Dasgupta and Stiglitz, 2000). Dahlsrud et al.

(2002) also emphasized social capital's importance in innovation systems as networks through which collaboration on and dissemination of new knowledge could take place. Social capital has been referred to as a dimension of a society or region within national boundaries (Gooteart and Serageldin, 2000) and therefore must be discussed in an examination of sociocultural dimensions relevant to innovation systems.

The social capital concept attempts to define the way social norms of behaviour, informal organizations, and formal institutions interact to affect economic outcomes (Solow, 2000). The debate on the subject centres around three points: whether the term social capital accurately describes the concept, what set of relationships, associations, and organizations are included in the concept, and how social capital affects economic growth in the aggregate. The following examines each of these points and then discusses social capital in relation to sociocultural dimensions that drive innovation.

### **Terminology and Measurement**

Some economists question the use of capital as the appropriate term for what they are attempting to describe in social capital. In economic theory, capital is a stock that can be measured and its costs quantified. Exactly how can the relationships of social capital be measured both in costs and productivity? Krishna (2000) states that social capital is a category of social assets that yields streams of benefits: assets are the stock of social capital, and the benefits are the flow. Robert Solow (2005: 6) states that the intent of the term is to define "the way a society's institutions and shared attitudes interact with the way its economy works." Solow disputes using the word capital to capture this concept and suggests that the term *patterns of behaviour* is more suitable because the costs and outputs of social capital cannot be measured in the aggregate.

The nature and impact of social capital are not easily quantified. Although World Bank professionals (Grooteart and Bastelaer, 2001) have created a Social Capital Assessment Tool, which combines quantitative and qualitative instruments to measure social capital at the level of household, community, and organization levels, it is not yet a tool that can be used to measure social-capital at a country level, if that is even possible. Social capital cannot be aggregated into a single indicator (Bangwayo-skeete et al., 2009).

### **The Set of Relationships**

The second debate questions what relationships and organizations should be included in social



capital. Grootaert and Serageldin (2000) offer three views. The most narrowly defined view focuses on the set of horizontal associations among people as the primary source of social capital. These include “networks of civic engagement and social norms, which are empirically associated and have important economic consequences.” (Putnam, 1993: 36). In his study on Italy, Putnam (1993) found that differences in per capita income between the north and the south were matched by differences in societal structure and the extent of civic community, citizen involvement, and governmental efficiency. He attributed the north’s higher per capita income to higher levels of social capital: horizontal social structures and a more efficient civic community versus hierarchical structures and less efficient civic structure in the south (Putnam, 1993).

A broader view of social capital includes not only the horizontal associations but also vertical structures and other entities. Sociologist Coleman (2000:36) sees the concept as a variety of different entities: “obligations and expectations, which depend on the trustworthiness of the social environment, information-flow capability, and norms accompanied by sanctions.” He demonstrated the value of social capital in forming human capital through his study of students remaining in high school until graduation versus dropping out. Both high social capital in the family and in the outside adult community offered considerable value in reducing the probability of dropping out of school (Coleman and Hoffer, 1987). Coleman also found that a form of social capital, which is valuable in facilitating certain actions, may be useless in other situations (Coleman, 1988).

**Table 3.1 Social Capital**

	Institutional Capital	Relational Capital
Basis of Collective Action	Transactions	Relations
Source of Motivation	Roles	Beliefs
Nature of Motivation	Maximizing behaviour	Appropriate behaviour
Examples	Markets, legal framework	Family, ethnicity, religion

(Krishna, 2000: 79).

A third view includes the “social and political environment that enables norms to develop and shapes social structure” (Grootaert and Serageldin, 2000: 45). This third view encompasses the first two definitions plus formal institutional relationships, such as government, political regimes, rule of law, and court systems. This view, as exhibited by Krishna (2000), suggests considering social capital in two distinct, related dimensions: (1) institutional capital, which refers to structural elements, and (2) relational capital, which refers to values, attitudes, and norms. He sees the two as

mutually re-enforcing and explains each in Table 3.1.

Krishna indicates that institutional capital results from relational capital within a society or from the interaction of the two. The task of building social capital lies in altering the thinking of individuals but “how to do so is vaguely known.” (Krishna, 2000: 90).

### **Social Capital and Economic Growth**

The effects of social capital on economic growth in the aggregate are difficult to quantify. Stiglitz (2000) provides a first step in understanding the relationship between markets and social capital as a society develops economically. The interpersonal networks that are in place in traditional, underdeveloped economies are partially replaced by formal institutions characteristic of a market-based economy. These would include a structured system of law imposed by a representative government. The process may cause depletion in the overall level of social capital but eventually lead to the creation of a type of social capital embedded in the economic system. This suggests the process of change and its affect on society but not its affect on economic growth.

Serragilden and Gootearte (2000:54) believe that there is a mix of types of social capital that produce optimal results to maximize economic outcomes. This mix depends on the process described by the macroeconomic production function and is constrained by resource endowment. This mix works something like technology’s affect. “...appropriate technology is not identified with formal economic models but is based on ad hoc insight and a thorough knowledge of a country.” They claim the same is true for social capital, which also enhances the efficiency of the combination process of the other factors of production.

It appears that the concept of social capital has been a process of development. As determinants of development are discovered and better understood through research and found to be lacking in the concept of social capital, the determinants are added as vehicles of social capital. The vehicles are increasingly more aligned with determinants of economic development rather than those of civic and social development.

From the literature on social capital, it can be concluded that the consensus on social capital lies in the plausibility that social networks can affect economic performance, primarily through trust, and that the value of social capital is intrinsic; that is, the interaction is its own reward (Arrow, 2000). Social capital can have a positive or negative effect on economic growth, and it seems the positive

effects can be measured in community situations, like remaining in school versus dropping out. Social capital could possibly be a shift factor that acts both positively and negatively on growth.

The literature also indicates that the lack of traditional social capital does not inhibit economic growth. Research on East Asian economies Hong Kong, Singapore, The Republic of Korea, and Taiwan, attribute their remarkable economic growth during 1980s and 1990s to an intense accumulation of physical and human capital, rather than specific Asian virtues of character and social organizations (Collins and Bosworth, 1996; Kim and Lau, 1996). Social capital is more the know-who that involves information about who knows what and requires a social capability to establish relationships to specialized groups.

Social capital affects a culture primarily through networks and trust. Social capital can have both positive and negative effects on socio-cultural factors that contribute to a knowledge-based economy. In places with strong traditional ties, social capital can promote stability and advantages to insiders (Florida, 2000; Granovetter, 1973). However, these ties are a barrier to new entrants and diverse groups who introduce novel ideas and innovations. Weak ties have been found to require less investment and can be used more opportunistically. They are critical to the creative process because they permit rapid entry of new people and absorption of new ideas (Florida, 2000).

Ultimately, the analysis of social capital has been complicated by the fact that different authors attribute characteristics to the concept. Should it be defined by its affects or its characteristics?

The problem with a functional definition is that it renders analysis impossible since, as argued by Alejandro Portes, social capital becomes tautologically present whenever a good outcome is observed. (Durlauf, 1999:2)

### **3.5.2 Trust**

Another entry point for culture into economic discourse is the concept of trust (Guiso et al., 2006). Putnam (2002) defined the components of social capital as associability, trust, and attention. Attention refers to the set of thoughts and opinions concerning social and political life. Associability defines one's engagement in informal networks or formal associations. "Trust means a general belief in the good will of others and their commitment to participate in dialogues for negotiating new realities." (Johannisson and Olaison, 2007: 58). The counterpart of trust is trustworthiness, which becomes relevant in hierarchical societies where codes of good conduct and honesty are confined to small circles of related people. Outside the small group, opportunistic

behaviours are considered natural and acceptable (Tabellini, 2008). This can determine economic behaviour for individuals as well as groups.

Fukuyama (1995) stated that communities depend on mutual trust and will not rise spontaneously without it. He spoke of a proclivity for spontaneous sociability, a capability for forming new groups or associations with others, as a factor in the ability to innovate organizationally. Fukuyama saw countries as being high trust, (e.g., Japan, Germany, the U.S.) or low trust (e.g., France, China, Korea). High or low trust depended on a country's proclivity for spontaneous sociability. America's penchant for spontaneous sociability allowed it to create the modern corporation. Japan's ability for the same allowed it to explore and create the *Keiretsu* system (Fukuyama, 1995). High trust or low trust is related to heritage: "Japan's stem(s) from family structure and the nature of Japanese feudalism. Germany's is related to survival of traditional communal organizations like the guilds... the United States is a product of sectarian protestant religious heritage." (Fukuyama, 1995:151). The homogenous Chinese culture stemmed from Confucian ethical principles, a society not ruled by laws but by internalizing the ethical system. Trust was kinship-based, and thus trusting professional managers from outside the family in a business context was not acceptable. Economically this accounted for the small scale of enterprises within Chinese owned firms. Growth happened through an increase in the number of enterprises, an advantage in some industries, such as labour-intensive sectors or rapidly changing sectors such as computers or toys. It does not create an advantage in capital intensive and highly complex manufacturing processes (Fukuyama, 1995).

Economists studied the economic payoff of trust (Knack and Keefer, 1995; La Porta et. al., 1997) and found that it could be incorporated into economic models as the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action (Gambetta, 2000). Although Fukuyama (1995: 26) himself did not differentiate between the trust that arises from better institutions and the cultural component of trust, he recognized that economists found that "trust is not necessary for cooperation: enlightened self-interest, together with legal mechanisms like contracts, compensates for an absence of trust and allows strangers jointly to create organizations that will work for a common purpose."

In economic literature the affect of culture on economic growth is often a two-step process that includes the effect on culture on a factor and then the affect of the factor on economic growth. For example, Guiso et al. (2006) looked at the effect of religion, a determinant of culture or prior belief, on trust to show that culture affected beliefs about trust. They then went on to demonstrate that

beliefs about trust affected economic outcomes. For example, trust can be relevant in a transaction when the exchange of goods and services and payment does not take place simultaneously, but legal financial instruments guarantee that the exchange will take place or repercussions will occur.

Trust as a cultural variable in economic models has limitations. First, it is difficult to measure. More importantly, people can develop trust in transactions because of the quality of the legal system or as a result of strategic interactions (Axelrod, 1984), as well as the result of an optimal investment in social capital (Glaeser et al., 2002).

### **3.6 Case Study**

Furman and Hayes (2004) found that a number of formerly industrializing economies had achieved levels of innovative capacity proportionate to or greater than those of some advanced economies during the 1979-2000 period. While innovation-enhancing policies and infrastructure were necessary to achieve this increased level of innovative capacity, they were insufficient unless accompanied by financial and human capital investment (Furman and Hayes, 2004). Additionally, Lundvall et. al. (1992) added that institutional setup and production structure constituted two important components that defined a system of innovation, yet other inputs were embedded in a socio-economic system in which political and cultural influences played a role.

A case study can demonstrate the development of an innovation systems approach within a knowledge-based economy. Among the newly innovating countries in the 1979-2000 period were Ireland, Singapore, South Korea, Taiwan, and Finland (Furman and Hayes, 2004). Research on the Asian Tigers' 20<sup>th</sup> century rapid development indicated that sociocultural factors played an insignificant role in determining success, based on the relative insignificant growth in TFP relative to capital accumulation (Collins and Bosworth, 1996; Kim and Lau, 1994). Therefore, Finland has been selected as a case study in which to examine sociocultural dimensions that played a role in Finland's success in increasing its innovative capacity. The selection has been based on the availability of considerable literature on the transformation of the Finnish economy in using an Innovation Systems approach. Dahlman, Routti, and Yia-Anttila (2006), in their seminal work on Finland as a knowledge-based economy, have attributed Finland's success to infrastructure, following a systems approach, and sociocultural dimensions of the Finnish people. The information that follows was extracted from their work, unless otherwise attributed.

### **3.6.1 Finland Background**

Until mid-twentieth century, Finland's economy was natural resource-based, on forest-related industries. The beginning of the Finnish knowledge-based economy occurred through user-producer linkages between the forest-based industries, as early users of high technology, and the emerging engineering, electronics and ICT industries in the 1960s and 1970s. This was an atypical pattern of industrial renewal, from natural-resource-based industries toward machinery, engineering, electronics, and ICT.

As late as the 1970s, Finland ranked at the lower end of the OECD countries in R&D intensity, yet, since 1980, government R&D investments, primarily in the private sector, have more than doubled to reach levels equivalent to 3.5% of GDP in 2004. The Finnish innovation system has been successful in converting its R&D investments and educational capacity into industrial and export strengths in the high-technology sectors.

### **3.6.2 Knowledge-based Economy Infrastructure**

Finland developed and maintained an infrastructure as required for a successful knowledge-based economy. This included:

- Strong rule of law
- Strong governance and accountability
- Stable macroeconomic policy
- Strong financial sector (after the 1990s crisis)
- Openness to outside ideas and a free trade regime
- Strong focus on encouraging domestic competition.

Openness to outside ideas and therefore, technology, was a noticeable feature of the development of the ICT industry (Dahlman et al, 2006), another infrastructure requirement of the knowledge-based economy.

Finland also had unique characteristics that differentiated it from other newly innovative countries in its emphasis on a welfare state, industrial policy, coordination of policies among key government agencies and the productive sector, and R&D and innovation (Furman and Hayes, 2004).

### **3.6.3 The Innovation Systems Approach**

The Finnish model applied a systems view to industrial policy. This systems view acknowledged

the importance of interdependencies among research organizations, universities, firms, and industries. Each organization had its a well-defined function within the national innovation system, yet collaborated with other organizations on everything from basic research and R&D to business development. Another consequence of the systems view was the high priority that the government gave to investments in R&D. The funding logic reflected the systems view of innovation in that it required that the stages of innovation be funded simultaneously. This demanded collaboration and coordination among the various public and private sector funding organizations. Major players in the innovation system set the framework or rules of the game to support innovative capacity. Following is a list of the players and their roles (Dahlman et. al, 2006).

- The Science and Technology Policy Council, chaired by the prime minister, manages the strategic development and coordination of Finnish science and technology and the national innovation system as a whole.
- The Academy of Finland promotes high-level scientific research. The primary objective is to promote long-term quality-based research funding, science policy expertise, and efforts to strengthen the position of science and scientific research. Approximately 15% of all government research funding is channelled through the Academy, which is administratively part of the Ministry of Education.
- The National Technology Agency (Tekes), founded in 1983, plays a major role in formulating innovation and technology policy by allocating funds for research and development to private firms, research organizations, and universities. It resides in the Ministry of Trade and Industry and allocates approximately 30% of the government's R&D budget.
- The Technical Research Centre of Finland (VTT), established in 1942, develops new technological solutions and applied technologies, to help clients improve their competitiveness. It also participates in national and international research programs and collaborative networks.
- The Finnish National Fund for Research and Development (Sitra), established in 1967 as a quasi endowment to promote experiment and new activities that would not be subject to budgetary delays and political commitments of government. Since 1991, it has operated as a public foundation under the Parliament.

In addition to the policy-making and funding organizations, education was and continues to be a key actor in Finland. The Finnish system supported equality by gender, region, and socioeconomic background. Higher education also emphasized economic trends and the demand for economically valuable skills relevant to development. These were taken into account in policy making.

### **3.6.4 Sociocultural Dimensions**

According to Dahlman et al. (2006) part of Finland's success could be attributed to dimensions or characteristics of the people. The first was attitude. The Finns had an independent spirit of self-reliance and a “can-do” mindset that were tempered by weather, geography, and occupations. The second was a strong spirit of cohesiveness, high moral values, an emphasis on equality, and relatively equal income distribution. These traits probably resulted partially from Finland's historical geographic isolation, homogeneous gene pool, and unique language. A third characteristic was a willingness to interact with the outside world in an open but strongly nationalistic way. Finns had a natural curiosity about the outside world that made them open to outside ideas and technology. Finns were among the first to introduce electricity and to use the telephone and were open to experimenting with and developing their own versions of telephone technologies almost as soon as they were invented.

Another dimension associated with Finland's success was the flexibility in its economy in responding to opportunity. This came about through:

- Availability of high-skilled workforce, idled by the collapse of other businesses
- Strength of the university and research infrastructure
- Quick response from the educational system in producing the needed new engineers, managers, and skilled workers
- Availability of foreign capital to fund the growth of the ICT sector
- Availability of venture capital and government seed funding to start up high-tech enterprises that became part of the ICT cluster that grew up around Nokia.

## **3.7 Sociocultural Dimensions Identified**

Characteristics of a knowledge-based economy were examined to reveal socio-cultural dimensions that underpin these characteristics in the transition to such an economy. Innovation literature was also investigated to better understand cultural traits that inspire innovation. The sociocultural dimensions that have been identified are a synthesis of these two sources and the discussion on social capital and trust, two topics so widely investigated by economic development academics that they could not be ignored.

Openness to outside influences facilitates exposure to and adoption of new technologies and ideas required to develop a knowledge-based economy and innovation within such an economy. Dahlman



et al. (2006) alluded to the Finns' "willingness to interact with the outside world in an open way" as a sociocultural dimension that helped the Finnish economy transition to a knowledge-based economy. Negroponte (2003) pointed out in his article on innovation that openness to outside influences encouraged creativity in introducing new perspectives.

A second key driver in innovation and the knowledge-based economy is openness in communication and a willingness to share information, without which knowledge as a factor of production cannot play its role. A fundamental component of NIS is the links among actors and institutions that encourage dissemination of new R&D and ideas from which increased innovation occurs. Just as in NIS, the MIT Media Lab found openness in communication and sharing information to be crucial to creativity.

A third dimension, as Negroponte (2003) pointed out, is risk taking. He found that the sociocultural dimension in the US of willingness to take risk and a lack of fear of failure to be key ingredients in driving creativity. Risk taking encourages innovation, allowing the adoption of the new with unknown or unexpected outcomes. When failure is stigmatized, economic and social agents are more likely to pursue new ideas and business ventures.

It has also been determined that interdisciplinary environments and diversity stimulate creativity. Negroponte (2003). This has been referred to as cognitive diversity (Page, 2008) to differentiate it from ethnic and preference diversity which often cause conflict. When various ethnic groups are disempowered, the cognitive diversity that leads to innovation cannot occur.

As the networked global society emerged in a knowledge-based economy, adaptability to a changing work environment, to enable transfer of knowledge or skills to a new set of parameters or new field, and in forming new groups and associations (Fukuyama's spontaneous sociability) allowed societies to meet the challenge and pace of change in the way business was conducted and lives were lived. This adaptability also translates into an economy's flexibility to adjust to opportunity, as occurred in Finland during a financial crisis of the 1990s. Hofstede (1980) saw uncertainty avoidance as measuring the ability of a society to deal with the inherent ambiguities and complexities of life. Cultures that are high in uncertainty avoidance rely heavily on written rules and regulations, embrace formal structures as a way of coping with uncertainty, and have little tolerance for ambiguity or change (Mueller & Thomas, 2001).

The shift from a knowledge-as-power base to one in which knowledge is openly shared requires a less authoritarian more egalitarian interaction. As Negroponte (2003) pointed, out inexperienced youth add value in offering new ways of thinking. The perspective of experienced professionals and respect for authority may not always lead to creative outcomes. A society that does not challenge authority may be said to be omniscient.

Without a level of human capital that can evaluate and adapt technology, as well as create its own indigenous innovation, foreign technology may simply become part of the static technology base. Therefore, an evaluative capability, what can be called functional literacy is required on the part of local populations to determine what and how to adopt as well as a certain know-how or tacit knowledge (Nelson and Phelps, 1996).

A high level of social capital within a society can have both positive and negative effects on sociocultural factors that contribute to a knowledge-based economy. Strong traditional social capital can promote stability and advantages to insiders but act as a barrier to new entrants and diverse groups who introduce novel ideas and innovations (Florida, 2000). Weak ties have been found to require less investment and can be used more opportunistically. They are critical to the creative process because they permit rapid entry of new people and absorption of new ideas (Florida, 2000). Putnam (2000) differentiated between bridging and bonding social capital. Bridging social capital provides a network that brings together a heterogeneous group while bonding social capital refers to a homogenous group. He agreed with Florida that bonding networks had a greater risk of producing negative externalities.

Trust as a cultural variable in economic models has limitations because it is difficult to measure and because it can be attributed to the quality of the legal system or a result of strategic interaction (Axelrod, 1984) rather than a sociocultural dimension of a society.

## **3.8 Gap in the Literature and Research Questions**

### ***3.8.1 Research Questions***

The questions that will guide this research include:

1. What sociocultural dimensions contribute to national innovative capacity?
2. What is the significance of these sociocultural dimensions in innovative capacity in GCC countries?

The questions will be stated as hypotheses at the end of the section.

### 3.8.2 Gap in the Literature

The research questions resulted from a gap in the literature. Literature on innovation and innovation systems discusses components of the system: actors and institutions and the links between them. Figure 3.1 depicts the Innovation Systems Framework. Literature on a knowledge-based economy indicates characteristics of such an economy and suggests that inner dynamism plays a role but refers to the term as “the intangible factors that makes society function efficiently and move forward...” (Aubert and Reiffers, 2003: 11). Literature suggests that economists agree that culture plays a role in economic growth, but they have not agreed on a precise list. Business literature on innovation has offered more precise sociocultural dimensions that contribute to creativity and innovation. Yet, little quantitative analysis is available that measures sociocultural dimensions’ contribution to innovative capacity. This research addresses this gap in the literature: by evaluating sociocultural dimensions that contribute to innovative capacity using a quantitative approach.

The previous discussions in this section produce a number of core sociocultural dimensions that appear relevant to innovative capacity within a knowledge-based economy. Table 3.1a lists the dimensions that will be tested. Table 3.1b lists the dimensions that have been discarded and the rationale for discarding them. Figure 3.2 depicts the Sociocultural Context as contributing to innovative capacity.

**Table 3.1a Sociocultural Dimensions Included**

Dimension	Description
Openness to outside influences	Required for new technology adoption, new ideas, communication in global economy, creativity.
Openness in communication	Required for sharing and disseminating knowledge and creativity.
Cognitive Diversity	Required for creativity and innovation.
Risk attitude	Required for creativity and entrepreneurial endeavors, spirit of independence and individuality.
Adaptability, flexibility	Required to apply skills to new situations and to adapt to changing work and social environments and an unknown future.

**Table 3.1b Sociocultural Dimensions Discarded**

Dimension	Description	Rationale for Omission
Independent spirit	Required for resilience and self-reliance.	Measurement issue. Hofstede's rating of individuality discarded because of researcher's intent to use only one Hofstede measurement.
Social capital	Required for networking.	Has pros and cons in measurement and definition issues.
Trust	Required for honesty in transactions.	Rule of law can take the place in business transactions. Measurement issues.
Non-authoritarian	Required for success in environment where knowledge-as-power transitions to knowledge sharing. Also required for creativity.	Measurement issue. Hofstede's rating for power distance discarded because of researcher's intent to use only one Hofstede measurement.

### **3.8.3 Hypotheses**

Clear and concise hypotheses are an essential part of the empirical process and help ensure that quantitative methods used meet the objectives of the research. The ultimate aim is to provide reasonable validity to logically viable propositions (Pontikakis, 2005).

The following hypotheses relate to leading and emerging innovator countries, as determined by Furman and others (2002), and provide insight into the first research question.

#### **H1: Openness to outside influences increases innovative capacity.**

Openness to outside influences facilitates exposure to and adoption of new technologies and ideas required to develop a knowledge-based economy and innovation within such an economy.

Openness to outside influences encourages creativity in introducing new perspectives. Dahlman alluded to the Finns' "willingness to interact with the outside world in an open way" as a sociocultural dimension that helped the Finnish economy transition to a knowledge-based economy.

#### **H2: Openness in communication increases innovative capacity.**

A second key driver in innovation and the knowledge-based economy is openness in communication and a willingness to share information, without which knowledge as an infinite factor of production cannot play its role increasing innovation.

**H3: Society's encouragement for risk taking increases innovative capacity.**

A third sociocultural dimension that effects innovative capacity is a society's risk taking perspective. The US' willingness to take risks and a lack of fear of failure were key ingredients in driving creativity. When failure is stigmatized, economic and social agents are less likely to pursue new ideas and business ventures.

**H4: Cognitive diversity increases innovative capacity.**

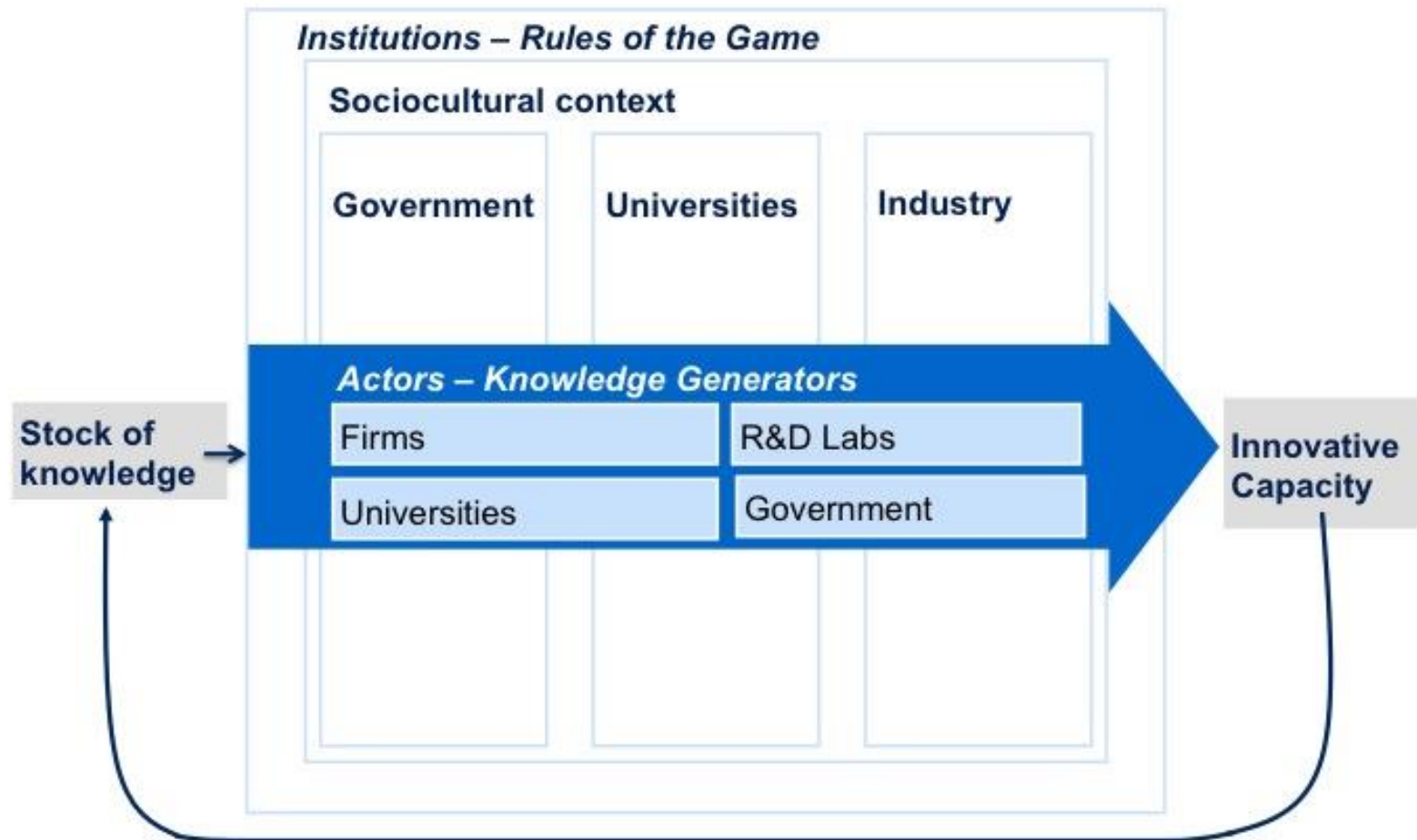
It has also been determined that interdisciplinary environments and diversity stimulate creativity. This has been referred to as cognitive diversity (Page, 2008) to differentiate it from ethnic and preference diversity, which often cause conflict.

**H5: Adaptability to changing circumstances increases to innovative capacity.**

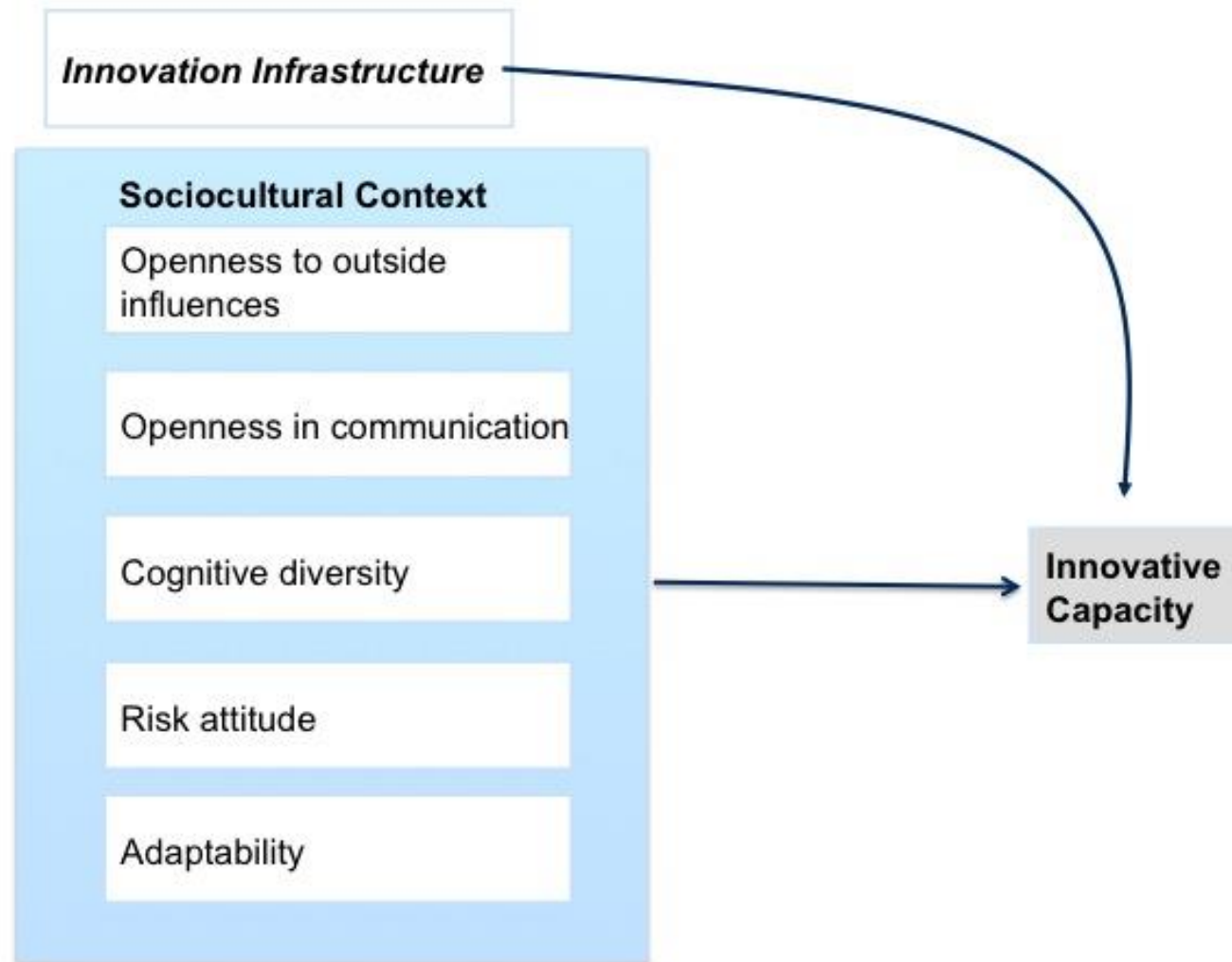
As the networked global society emerged in a knowledge-based economy, adaptability to a changing work environment, to enable transfer of skills to a new set of parameters, and in forming new associations (Fukuyama's spontaneous sociability) allowed societies to meet the challenge and pace of change in the way business and life were conducted. This adaptability also translates into an economy's flexibility to adjust to opportunity, as occurred in Finland during a financial crisis of the 1990s. Hofstede (1980) saw uncertainty avoidance as measuring the ability of a society to deal with the inherent ambiguities and complexities of life. Cultures that were high in uncertainty avoidance relied heavily on written rules and regulations, embraced formal structures as a way of coping with uncertainty, and had little tolerance for ambiguity or change (Mueller & Thomas, 2001).

The significance of sociocultural dimensions in innovative capacity in GCC countries will be tested as a subset of the dataset for the years 2000-2010, the years in which the GCC has focused on developing knowledge-based economies.

**Figure 3.1 Framework for Innovation Systems**



**Figure 3.2 Sociocultural Context**



## **Chapter 4 The Gulf Cooperation Council (GCC)**



## 4.1 Introduction

The Gulf Cooperation Council is a loose political and economic alliance of six Persian-Arab Gulf states, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. The initial goal of the GCC was to boost economic cooperation among members and provide security from interference by neighboring countries (Foundations, n.d.). Its members share similar political systems, tribal heritages, and a common religion, Islam (Ramazani and Kechichian, 1988). The governments are autocratic monarchies or sheikhdoms, which allow limited political participation. Collectively, GCC countries possess 35.7% of the global proven oil reserves and 20% of the world's gas reserves ([www.gulfbase.com](http://www.gulfbase.com)). It is claimed that they share a social and cultural perspective as well, although they differ in the way they have responded to the large expatriate workforce and globalization.

The objectives of focusing on GCC countries in this research are three. First, the countries are cushioned against economic shock through natural resource wealth, and the “urgency to survive” has not been the primary driver in achieving economic growth. Because of globalization and social pressures due to unemployment and inequity in wealth distribution, the countries have stated their intents to develop knowledge-based economies (UNDP, 2009), of which an innovation system is a pillar (Chen and Dahlman, 2004). While GCC countries have made considerable investments in information and communication technology, in education, and in developing a supportive economic regime, the outcome has not resulted in a strong innovation system pillar (UNDP, 2009). The lack of relevant sociocultural dimensions that support innovation may be partially responsible.

Second, a better understanding of sociocultural dimensions will allow the GCC to improve its own policy initiatives and domestic investment strategy. These economies have significantly improved their economic regimes and shortened the time and processes in starting a new business, for example. The question remains whether this is a policy that stimulates innovation in these societies. The investment in education and ICT is large and much discussed but is the implementation of educational policy leading to increased innovative capacity in the long term?

Third, GCC countries have funding organizations (see Table 3.2) that invest in developing country projects and infrastructure. Understanding sociocultural factors that are relevant to increasing innovative capacity in these countries can aid fund management in improving its investment strategies and in aiding the development other economies.

What follows is a historical brief on GCC countries, a discussion of their common heritage, and a description of current affairs. This is followed by an examination of what is known of policy and data that indicates the status of GCC innovation systems. Generally, the knowledge-based economy and innovation systems within GCC countries had been addressed in literature about the Arab World as a whole (UNDP, 2009; Nour, 2005). Unfortunately, a monitoring organization “that prepares indices for the Arab region and guarantees credibility of data on research and the dissemination of science and innovation within it” is lacking (UNDP, 2009: 181). Nevertheless, varied data concerning indicators of readiness for the knowledge-based economy and supportive infrastructure for innovation systems is available and will be discussed here. A conclusion offers a perspective on country attributes that should be considered in developing an innovation system.

## **4.2 Historical Perspective**

### ***4.2.1 Country Specifics***

Each GCC country history has been characterized by a close relationship with the British Empire, through becoming a British protectorate: Bahrain in 1861, Kuwait in 1897, Qatar in 1916, or forming a special relationship, mostly over oil and defense: Oman and the UAE. Independence for four of the countries came in the 20<sup>th</sup> century. The UAE was formed in 1971 with six emirates - Abu Dhabi, Ajman, Al Fujairah, Sharjah, Dubai, and Umm al Qwayn – was joined by Ras al Khaimah in 1972 (Rugh, 2007). Bahrain became independent in 1971, Qatar in 1971, and Kuwait in 1961. The two larger countries Saudi Arabia and Oman had somewhat different histories. Oman forced the Ottoman Turks out in 1751, and the Wahabis consolidated authority in Saudi Arabia by 1811, and the modern Saudi state was founded in 1932. (Factbook, 2010)

Ruling families have had longevity, and change in rulers, other than through succession, has occurred through family intervention. For example, the Qatari Emir from the ruling Al Thani family was corrupt and therefore overthrown by his son in a bloodless coup in the 1990s. The al-Sabah family has ruled Kuwait since mid 18<sup>th</sup> century. The Al Khalifas, current ruling family of Bahrain, migrated to Bahrain island in the last quarter of the 18<sup>th</sup> century to escape the Wahabis, the political-religious power from the Saudi interior (Bahrain Profile, 2013). A predecessor of the current ruling family in Oman forced the Ottoman Turks out of the country in 1741. The ruler of the UAE comes from the Nahyan family of Abu Dhabi, the largest emirate, and the family has ruled

Abu Dhabi since 1793. Saudi Arabia has been ruled by a branch of the al-Saud family since the 18<sup>th</sup> century, though the modern state was formed in 1932. (Factbook, 2010)

Prior to the discovery of oil, the countries eked out a living in pearl fishing, agriculture, and trade, and existence was primarily nomadic (Nakhleh, 1986) Bahrain, because of its small size, central location, and small oil reserves, has had to play a balancing act in foreign affairs among its larger neighbours. In addition, the Sunni-led government has struggled to manage relations with its large Shia-majority population, another basis for conflict with 98% Shia Iran (Factbook, 2010). Bahrain was one of the first states to discover oil (1932) and build a refinery, yet it never had the reserves of other Gulf states, and therefore, was one of the first to develop its communication and transport facilities to diversify its economy. Petroleum production and refining accounted for more than 60% of Bahrain's export receipts, 70% of government revenues, and 11% of GDP (Factbook, 2010).

Oil was discovered in Kuwait in the 1930s, and since 1946, the country has been the world's second-largest oil exporter. Petroleum accounts for nearly half of GDP, 95% of export revenues, and 95% of government income (Factbook, 2010).

Oman's oil exploration started in 1925, and because production has been modest relative to other GCC countries, it has prospered on Indian Ocean trade and fishing, pearl diving and more recently, on tourism (Factbook, 2010).

Qatar discovered oil in the 1940's, and oil and gas still account for more than 50% of GDP, roughly 85% of export earnings, and 70% of government revenues. Oil and gas have made Qatar the highest per capita GDP country in the world with the lowest unemployment (Top 10, 2012).

Saudi Arabia, the largest economy in the GCC, is considered the homeland of the Arabs and the world's second largest religion, Islam. It is the location of the two Moslem holy pilgrimage cities of Mecca and Medina and thus has considerable influence in the Moslem world (Factbook, 2010). Oil was discovered in 1936 in Saudi Arabia, and commercial production began during World War II (Cordeman, 2003). The petroleum sector accounts for roughly 80% of budget revenues, 45% of GDP, and 90% of export earnings. To better understand the role oil plays in the economy, falling demand and rising production outside OPEC reduced oil revenues from \$120 billion in 1980 to less than \$25 billion in 1985 (Factbook, 2010).

Since its first oil concession in 1939, the UAE has undergone a profound transformation from an impoverished region of small desert principalities to a modern state with a high standard of living (Al Fahim, 1995). Emirates vary in their level of oil reserves, and Abu Dhabi with the largest reserves, dominates in political matters. Dubai led the push for diversification of GDP and had the highest global profile because of a leader's vision and development objectives (Dubai's GDP, 2001). Dependence on oil and gas (35% of GDP), a large expatriate workforce, and growing inflation pressures are significant long-term challenges, as is true for all GCC countries. (Factbook, 2010).

#### **4.2.2 Common Heritage**

##### **Nomadic and Tribal Society**

GCC countries share a tribal heritage which has affected their modern leadership style, culture, and family interactions. In GCC tribal society allegiances shifted according to opportunity and the needs of the tribes and communities, combining or fragmenting depending on political goals to gain dominance over other tribes. Sheikhs lined up strategic tribes to expand or protect their interests (Heard-Bey, 1982). Governance was based on personal relationships, not institutions, and focused on personalities and social networks to support them. A leader's position was based on his ability to dominate outside political and economic influences and resources (Rugh, 2007). Nomadic existence reinforced the system in that tribes could pick up and leave if a ruler was not fit. Scattered inhabitants conflicted less and problems could be solved easily by tribal rule. The system could be described as a rough form of participatory politics in that without followers, a leader could only achieve limited objectives. Checks and balances were embedded in social norms, and peoples' strong desire to maintain their reputations inhibited them from violating tribal norms (Rugh, 2007). The system was effective as long as a ruler could engage in face-to-face contact with those who had power within a community and explains the *Majlis* concept that still exists today.

In traditional society the order of importance in personal relations were family first, tribal affiliation, and then outsiders. "It was assumed that people in a moral society had obligations towards each other...morality came from a belief that responsibilities were god-given not man-made, as are rights and entitlements" (Rugh, 2007: 220). They had close ties with family but loose ties when a situation demanded. The family unit was hierarchical and with authority residing at the top and each member having fixed responsibilities to each other (Heard-Bey, 1982).

Oil changed the possibility for nomadic life in two fundamental ways. With oil, it became mandatory that internal boundaries be fixed so that the oil companies would know to whom to pay oil revenues. Because of oil wealth and royalty payments, the leader of the geographic area gained power through wealth rather than because they were successful in creating alliances with other tribes (Rugh, 2007).

## **Islam**

Social organization demanded by the desert and tribal society took place against the backdrop of Islam from the 7<sup>th</sup> century AD. Islam is an all encompassing system incorporating religious, political, financial, and legal systems (Lewis and Churchill, 2008). Therefore, instruments of Islam are relevant to this discussion on sociocultural dimensions in affecting overall GCC infrastructure and attitudes.

Muslims base their laws on their holy book, the Koran, and the Sunnah, the practical example of Prophet Muhammad. The five basic pillars of Islam include the declaration of faith, praying five times per day, giving money to charity, fasting during the holy month of Ramadan, and making a pilgrimage to Mecca (Lewis and Churchill, 2008). During the fasting month of Ramadan, restaurants and cafes are closed until sunset, except at Western style hotels where restaurants may open if the entrance is covered by a curtain or screen. Alcohol is forbidden in Saudi Arabia and Kuwait at all times and is not served during Ramadan in other GCC countries, with the exception of hotels in the UAE and Oman. The call to prayer is broadcast five times per day in all GCC countries, and in Saudi Arabia, all business stops for thirty minutes five times per day (researcher experience).

In the Islamic value system wealth is a favour of God and should therefore be used by man moderately to satisfy basic needs. Material wealth does not entail higher status nor merit (Harris and Moran, 1987). Every activity is regulated by the Koran, and institutions are difficult to alter unless the *ulema*, who interpret the Koran, favour change (Landes, 1999). Change is high risk and therefore innovation may be affected by Islamic belief in a negative way.

There is certain ambivalence about the concept of innovation, which is rooted in a misinterpretation of religious precepts and is made worse by linguistic ambiguity. The word “innovation” can be interpreted as *bidaa*, which is frowned upon as a negation of the precepts of the Koran, or as *Ibdaa*,

which is encouraged as a way to renewal and enrichment. It is obvious that those who interpret innovation as *bidaa* oppose innovation and may even rise against it (Aubert, 2003: 30).

Islam gave GCC countries a common economic legacy and therefore affected economic patterns, as well as shaped political possibilities. Kuran (2012) pointed out that while initially specific Islamic institutions or dictates had positive intent and were morally suitable, their enforcement led to unexpected outcomes that he saw as detrimental to the construction of modern institutions in government and business. Three are discussed below.

The tax system, *zakat*, is a tithing system in which wealthier citizens were required to make fixed annual contributions, with a ceiling on obligatory amounts. Because exemptions were possible, rulers granted them to build political alliances, as already discussed. Because the system was not enforced with equity and predictability, states or rulers became unable to raise the necessary revenue for public good, and taxes were raised, but without the cap placed on *zakat* through Islamic law. The arbitrariness of enforcement and predictability set a pattern, which despite the natural resource wealth now available to government, still exists.

A second Islamic institution, *waqf*, an endowment or trust, allowed for the income of funds or property to be permanently reserved for a designated social service (Hoexter, 1998). The concept did not permit autonomy or self-governance of the property by the founder(s) of the *waqf* because objectives and procedures were fixed from the initial founding. Although the funds were shielded from government seizure, the lack of flexibility to manage the trust in accordance with current economic dictates meant that the funds could become large, but as an entity, could never become a power that may counterbalance the ruler or government. Eventually, trustees were able to take advantage of new procedures and financial instruments to reallocate *waqf* resources, but this was managed outside the law (Kuran, 2012). Kuran believed that this added to the custom of requesting or receiving special dispensations, making it difficult to enforce rules and regulations in other categories.

Islamic commercial partnerships allowed a member to pull out of the partnership unilaterally, and the remaining partner would bear whatever costs occurred because of the dissolution of the partnership. Thus, partnerships were either of short duration or with family members. Short-lived partnerships did not help develop large business entities that would have enjoyed more economic power and could act as a counter-balancing force to government, and when appropriate, make the

government aware of legislation required to improve functioning of businesses and other institutions for the good of society (Kuran, 2012).

The outcome of the three institutions above has been that checks and balances on public and private entities have been weak. While modern civil law has been developed to replace or counter balance the functioning of outdated institutions, the region is still in a transition state in developing institutions that improve operation in the modern knowledge-based economy and affect an innovation system strategy.

## **4.3 Current State of Affairs**

Although sharing similar world views, tribal heritage, and religion, each GCC country has followed its own economic development and modernization path and prospered depending on how they adapted to changing circumstances.

### ***4.3.1 Social and Political Dissension***

With the exception of Qatar, GCC countries seized the opportunity of the Arab spring of 2011 to voice dissension with the government to a greater or lesser extent. This reveals an undercurrent of dissension with the government in its ability to solve employment and other socioeconomic issues. It also indicates an expectation that government can and will solve these issues rather than individuals coming together to define a course of action. Many of the grievances against the government were related to housing, government jobs, which are highly desired because of short working hours and benefits, and political participation (The National, 2011). However, overall the GCC citizens' responses to the Arab Spring were modest compared to Egypt and Libya.

In Bahrain, for example, the Shia majority petitioned for the government to redress popular grievances such as housing and government jobs. While the King agreed to meet with the opposition and implement changes according to a commission of inquiry set up by the government, the outcome is still unknown. Bahrain experienced economic setbacks as a result of this domestic unrest, and its reputation as a financial hub of the Gulf has been damaged (Colombo, 2012).

Omanis staged marches and demonstrations to demand economic benefits, an end to corruption, and greater political rights, and Sultan Qaboos pledged to create more government jobs and promised to implement economic and political reform (Colombo, 2012).

In Kuwait stateless Arabs (non passport holders) protested their status, and this encouraged youth groups to rally to end corruption. Relationships between the partially elected National Assembly and the executive branch are problematic. Prior to the Arab Spring, Kuwait had passed an economic development plan that pledged to spend up to \$130 billion over five years to diversify the economy away from oil, attract more investment, and boost private sector participation in the economy (Colombo, 2012).

The Arab Spring sparked modest incidents in Saudi cities, predominantly by Shia demonstrators calling for the release of detainees and the withdrawal of the GCC Peninsula Shield Forces from Bahrain. In response to the unrest, the King announced a series of benefits to Saudi citizens, including funds to build affordable housing, salary increases for government workers, and unemployment benefits. Most senior princes believe that the future lies in peaceful political evolution, avoiding religious extremism, quality of education, and economic development (Cordesman, 2005). The government has substantially boosted spending on job training and education and plans to spend \$373 billion between 2010 and 2013 on social development and infrastructure projects to advance Saudi Arabia's economic development (Colombo, 2012).

Emirati activists and intellectuals reacted to the Arab Spring by sending the government a petition calling for greater political reform, including the establishment of a parliament with full legislative powers, and the further expansion of the electorate and the rights of the Federal National Council (FNC), the UAE's quasi-legislature. To stem further unrest, the government announced a multi-year, \$1.6-billion infrastructure investment plan for the poorer northern Emirates. Voting for a portion of the FNC seats was to be expanded to include 12% of the Emirati population (Colombo, 2012).

#### ***4.3.2 Innovation System***

Innovation systems within the GCC are generally covered in literature on innovation in the Arab World as a whole (UNDP, 2009). This is also true for initiatives and strategies that are set forth in conferences, such as the Arab League Educational, Cultural, and Scientific Organization meeting, 2005 and 2007, and the Arab Economic and Social Summit, 2009. However, what is true of the Arab region as a whole does not necessarily apply to GCC countries because of their natural resource wealth. Therefore, the researcher will present characteristics of innovation systems as they are revealed in data about the GCC.



Table 4.1 (data from <http://www.worldbank.org>) indicates that GCC country readiness for a knowledge-based economy, as measured by the Knowledge-Assessment-Methodology framework from the World Bank (Chen and Dahlman, 2004). For the years 2000 and 2012, indicators suggest that GCC performance in innovation, relative to other indicators, greatly improved in the UAE and Qatar, decreased in Bahrain, and remained relatively stable for other countries. In comparison to Denmark and Finland, two emerging innovator economies (Furman and Hayes, 2004), GCC countries have not yet attained an innovator country status. Another indicator of commitment to innovation is a positive correlation between GDP growth and the innovation index (UNDP, 2009). The growth in GDP per capita within the GCC (Table 4.2) suggests that innovation growth is not keeping up with GDP growth, except perhaps in the UAE and Qatar.

Science and Technology policies of GCC countries can be determined partially through research and development organizations established by the government. Appendix I provides a list of what were referred to as research organizations in a presentation made by the UAE's National Research Foundation in 2011 (Al Ulama, 2011). Research and development centres generally function through ministries of higher education and scientific research, ministries of education, or ministries of planning (UNDP, 2009). Kuwait, Bahrain, the UAE, and Qatar have assigned the task to relatively independent councils or academies (Salih, 2008 in Arabic from UNDP, 2009). Saudi Arabia has established a technological city, and Qatar established a Technology Oasis under the umbrellas of the Qatar Foundation (See Appendix I).

Many of the organizations (Appendix I) have been in existence since the 20<sup>th</sup> century, and the primary objective has not been innovation. Analysing the different organizations by country reveals that Kuwait was one of the first GCC countries to openly offer project funding to other Arab countries. Several characteristics of the Kuwaiti organizations are worth noting. The primary objective of the development work is not innovation but rather infrastructure development. Funding of the organizations is not always apparent; the assumption is that the entity is government funded. Loans are made through the organizations, and because interest is forbidden in Islam, it would be assumed that terms of the loan must include a fee as the most appropriate method of paying for the use of the money. It is also not clear whether the organizations are profit oriented or non-profit.

Education and new knowledge development in Qatar has taken place under the Qatar Foundation. The Foundation established Education City in Doha and invited well-respected faculties of several

universities to establish faculties there (Fromherz, 2012). It is noteworthy that the foundation invited the most well respected faculty(ies) from each university, which indicates Qatar's quality aspirations. The faculties include Engineering from Texas A&M, Medical from Cornell, Foreign Service from Georgetown, and Journalism from Northwestern (Fromherz, 2012). Whether this investment has led to increased innovative capacity has not yet been evaluated.

While the presentation (Al Ulama, 2011) listed two entities for Oman, little can be determined about their output thus far. It is more likely that Shell Oil, with whom Oman has developed its oil industry, has been the source of innovation in Oman. While the web sites for the two Saudi entities list project types, little of their outcome has been cited in other publications. One organization is dedicated to education while the other, KACST, is dedicated to science and technology in diverse fields (Appendix I).

The UAE research bodies are more diverse than those of other countries. All are funded by the government and/or royal families. These organizations are focused on developing a well-functioning society, not just science and technology. This matches the expanded sense of innovation for the Arab World as not only including scientific and technical ingenuity but also culture and the arts (UNDP, 2009).

Examining commitments to technology, education, and innovation reveals more about policy. We have learned that investment in R&D is one driver of innovation. Yet, percentage of GDP investment in R&D (GERD) has not increased significantly since 2000. Table 4.2 indicates figures reported by Kuwait, .13% in 2000 and .11% in 2010, and Saudi Arabia, .05% in 2000 and .08% in 2010. These figures are below those of emerging innovators Finland, 3.35% in 2000 and to 3.88% in 2010, and Denmark: 2.39% in 2001 and 3.06% in 2010. (Science and Technology Indicators, <http://www.worldbank.org>). A resolution that cooperation in scientific research and an increase of expenditure on research should be increased to 2.5% within the next ten years was written into the ten-year plan for scientific research and development approved at the 2007 Arab Summit held in Saudi Arabia (UNDP, 2009). According to the figures, this has not yet occurred.

Education develops the human capital required for innovation, and public spending on education as a percent of GDP increased in Oman and decreased in Saudi Arabia. Although figures for 2000, 2005, and 2010 (Table 4.2) were not available for all countries, the percent GDP is impressive when compared to Denmark, 8.7% in 2000 and 8.7% in 2009, and Finland, 5.9% in 2000 and 6.8%

in 2009. The investment demonstrates the commitment to the education sector. However, the average years of schooling has not increased substantially over the 11-year period under investigation (Table 4.2). Also relevant to a discussion on education and development of human capital is the role university faculty is expected to play in research. Teaching faculty in the Arab World are expected to teach twice the class load of those in the Western World, 3 classes per semester in the West to 6 classes per semester in most Arab universities. Research in western universities may be 35-50% of academic duties whereas in the Arab world, it is 5-10% (UNDP, 2009). The general population's access to the Internet has tripled in some cases, with the highest penetration in Qatar at 81.6% and the UAE at 68%. This rate is not yet at a level matching emerging innovator countries such as Denmark at 88.7% and Finland at 86.9% in 2010. However, it does indicate a commitment on the part of the governments to provide the population access to technology and the outside world. Telecommunications company are partially or totally owned by the government (Aubert, 2003).

Articles in Science and Technology (S&T) publications and new patents are an indication of innovation output (See Literature Review 2.8 Innovation Systems Methods of Analysis). While S&T articles within the GCC have increased over time (Table 4.2), the number of articles in S&T publications is low compared to Denmark, 5,306 in 2009 and Finland, 4,949 in 2009. The UAE has a larger population, 7 million, than Denmark and Finland, each with 5 million plus in 2009. Patents (Table 4.2) registered with the USPTO fall far below the count for emerging innovators Denmark, 766 patents in 2010, and Finland, 1232 patents in 2010.

Given the wealth in natural resources that GCC countries have, it would seem that the oil and gas companies would lead the way in the emphasis on innovation. A glance at the web sites of the oil companies owned by GCC governments and USPTO information indicate the status of oil company innovation. With the exception of Saudi Aramco, a search of oil company web sites for innovation and patents produces lists of presentations and awards but no lists of patents nor of innovations specifically. A search of the USPTO database for patents owned by the oil companies reveals that in fact the oil companies do own patents. (See Table 4.2 c.)

Overall, the UAE has seen greater increase in its innovative capacity. Dubai has led the way by formulating a vision and planning stages in transition. As Aubert et al. (2003) stated, the transition started with the vision of the ruler, Sheikh Mohammed, embracing the knowledge-based economy as strategy for Dubai's economic growth model. The strategy envisioned the creation of services,

products, applications, and employment in the areas of IT, the Internet, data processing and telephony. Appropriate labour laws were implemented to attract foreign competencies. The strategy encompassed three phases. Phase 1 focused on Dubai's assets in trade, logistics, transportation, and tourism. Its market objective was to transform Dubai into a global hub to act as a regional leader and a bridge between Europe and Asia (Aubert et al., 2003). Social objectives involved building a class of knowledge workers, "so that young and dynamic entrepreneurs and business leaders could contribute to Dubai's integration into the global community without loss of identity" (Aubert et al., 2003:58). The economic objective was a 30% increase in GDP within 10 years: 25% in the knowledge economy and 70% in the overall services sector (58). The transformation was to be facilitated by an open market economy in the form of a free trade zone.

Phase 2 involved the application of core competencies to new areas such as technology, financial services, media, telecommunications, and IT. The structural base was technology, e-commerce, and media clusters consisting of three separate business entities: Dubai Internet City, Media City, and the Knowledge Village. This has expanded to include other clusters centred on universities and medicine. It was intended that these entities provide concrete knowledge economy applications in the form of visible projects (Aubert et al., 2003).

Finally, Phase 3 is being built upon the revenues leveraged in Phase 1 and 2, which were invested to project and develop future competencies. Dubai is currently looking into new developments in R&D, education, and emerging sectors such as pharmaceuticals, biotechnology, nanotechnology, and wireless (Aubert et al., 2003)

Examining policy outcomes as reflected in the World Economic Forum Global Competitiveness indicators provides another indication of GCC progress in developing an infrastructure conducive to innovation. Information is provided from The Arab World Global Competitiveness Review 2010, unless otherwise indicated. See Appendix II.

Competitiveness indicators are divided into twelve pillars spread among three categories. The categories are Basic Requirements, Efficiency Enhancers, and Innovation and Sophistication Factors (WEO, 2010). Pillars, as listed in Appendix II, include rankings from 1-139 (139 countries were in the survey.) Meeting basic requirements indicates that a country is a factor driven economy. Meeting efficiency enhancers classifies a country as an efficiency driven economy. Meeting innovation and sophistication factors indicates that a country is innovation driven (WEO, 2010).

Qatar, Kuwait, and Saudi Arabia are considered to be in transition from stage 1, meeting the basic requirements to stage 2. Bahrain and Oman are in transition from stage 2 to stage 3, and the UAE is considered to be in stage 3, an innovation driven economy. The Gulf region has made significant improvement on all measures, and GCC members outperform all other Middle Eastern Countries, except on market size and reach.

Appendix II provides an example of different levels of innovation ratings relative to categories described in Furman and Hayes (2004). On these indicators, Bahrain and Kuwait are not well positioned to increase their innovative capacity given their low ratings on R&D research institutes, R&D company spending, and university collaboration. Qatar and the UAE seem best positioned for their future innovative capacity because of their rating on government procurement of technology products, which indicates government support for technology, a mandatory step in increasing innovation. Engaging the private sector in innovation is another ingredient in the overall recipe for innovation, and Saudi Arabia and the UAE indicate that the private sector recognizes this through company spending. The Kuwaiti rating is surprising given the funds available through her funding organizations. Overall, GCC countries demonstrate investment, both public and private, in R&D and technology, except for Kuwait. Their general innovative capacity is low relative to this investment, indicating that indigenous innovation should be one of the GCC's priorities to play catch up relative to the investment they are willing to make in innovation.

Comparing GCC country ratings on the Innovation Pillar with two emerging innovators (Appendix II) as defined by Furman and Hayes (2004), indicates that a key area to improve is attracting tertiary students to Science and Engineering studies and attracting that talent to work in the research institutes and universities.

## **4.5 Conclusion**

From the discussion on GCC countries, shared sociocultural dimensions emerge. One would consider the GCC population to be resilient because of its struggle to survive in a desert climate with meagre resources. Yet their struggle meant that interference and group survival were paramount, and group inclusion was not extended to outsiders and happened through competition and often conflict. The importance of family and group think determined with whom one interacted, both socially and on a business level. This indicates traditional social capital as per Putnam (1993)

rather than Florida (2002). Florida found that loose, fluid ties were more conducive to creativity and creative capital. Additionally, strong group affiliation rather than individualism contributes to a risk-averse attitude. (Hofstede, 1980)

The Islamic heritage appears to emphasize a strict and narrow adherence to religious dictates in appearance but underneath there is a search for special treatment or dispensation from following the dictates, which can be problematic for a modern state. At the same time it indicates that adaptability to changing circumstances must be inherent in such a system. The development of institutions in political or social contexts is in a transition stage.

Ruling family reactions to events of the Arab Spring, while generous, appear in the form of benevolence. The ruler hands out funds, jobs, and other concessions rather than citizens earning them. Voting rights to bodies without power offer little in civic participation and civil rights that empower society. A more interesting phenomenon is the way that Ramadan is managed in GCC countries in comparison to other Moslem countries. While Moslems in other countries fast, the country does not shut down nor force others to follow the dictates of religion. People are permitted to eat openly. One must question how far these dictates teach a sense of responsibility or sacrifice for participants.

While developing a strong innovation system has been deemed paramount in strategies and initiatives, indicators on investment in R&D and innovation output in S&T publications and patents reveal that GCC countries are in the initial stage of developing an innovation system. Dubai may lead the way in this endeavour. Dubai was deeply affected by the financial crisis and property market crash in 2009 and lacked sufficient cash to meet its debt obligations. The UAE Central Bank and Abu Dhabi-based banks bought the largest shares of its debt, and Abu Dhabi provided additional funds in a \$10 billion loan. Dubai has shown resilience in rebuilding its economy and has created an expanded strategy in its maritime and shipping endeavours (conversation with Dubai Director of Maritime Strategy) and is moving forward with a new initiative on competitiveness for the future.

The primary challenge for the region is to find work for the young work force (see low median age and the large expatriate workforce in Table 4.2). This reinforces the requirement for an education that emphasizes creativity, ability to transfer knowledge to new situations, and critical thinking, as well as strong science and engineering faculties, required for innovation. It also emphasizes that the

current power structure in business and society must be willing to empower youth and a new way of thinking. While Saudi Arabia and the UAE have the same rating in global competitiveness (Appendix II), the UAE significantly surpasses Saudi in civil development, openness to outside influences, and freedom of social interaction. One can only assume that global competitiveness is heavily weighted towards capital and GDP. Is this the measurement that will lead to an innovative knowledge-based economy?

**Table 4.1a Knowledge Assessment Methodology Ratings – GCC – 2000**

	<b>KEI</b>	<b>Economic</b>	<b>Innovation</b>	<b>Education</b>	<b>ICT</b>
Bahrain	6.85	7.45	6.37	6.34	7.26
Kuwait	6.16	7.00	5.38	5.17	7.09
Oman	5.28	7.51	4.25	4.22	5.12
Qatar	6.01	6.64	5.51	4.85	7.05
Saudi Arabia	4.60	4.40	4.24	4.28	5.49
United Arab Emirates	6.05	7.51	4.32	4.44	7.92

Source: Knowledge Assessment Methodology, The World Bank,

**Table 4.1b Knowledge Assessment Methodology Ratings – GCC – 2012**

	<b>KEI</b>	<b>Economic</b>	<b>Innovation</b>	<b>Education</b>	<b>ICT</b>
Bahrain	6.90	6.69	4.61	6.78	9.54
Kuwait	5.33	5.86	5.22	3.70	6.53
Oman	6.14	6.96	5.88	5.23	6.49
Qatar	5.84	6.87	6.42	3.41	6.65
Saudi Arabia	5.96	5.68	4.14	5.65	8.37
United Arab Emirates	6.94	6.50	6.60	5.80	8.88

Source: Knowledge Assessment Methodology, The World Bank,

**Table 4.1c Knowledge Assessment Methodology Ratings – Emerging Innovator Example – 2000**

	<b>KEI</b>	<b>Economic</b>	<b>Innovation</b>	<b>Education</b>	<b>ICT</b>
Denmark	9.32	9.15	9.52	8.99	9.63
Finland	9.22	9.50	9.68	8.31	9.37

Source: Knowledge Assessment Methodology, The World Bank,

**Table 4.1d Knowledge Assessment Methodology Ratings – Emerging Innovator Example – 2012**

	<b>KEI</b>	<b>Economic</b>	<b>Innovation</b>	<b>Education</b>	<b>ICT</b>
Denmark	9.16	9.63	9.49	8.63	8.88
Finland	9.33	9.65	9.66	8.77	9.22

Source: Knowledge Assessment Methodology, The World Bank,



**Table 4.2a GCC Country Data**

	<b>2000</b>	<b>2005</b>	<b>2010</b>
<b>GERD as % GDP</b>			
Kuwait	0.13	0.1	0.11
Saudi Arabia	0.05	0.04	0.08
<b>S&amp;T Pubs</b>	<b>21</b>	<b>33</b>	<b>36</b>
Bahrain	238	234	214
Kuwait	92	111	114
Oman	17	39	64
Qatar	590	576	710
Saudi Arabia	145	229	265
UAE	145	229	265
<b>Patents</b>			
Bahrain	4	5	56
Kuwait	45	78	126
Oman	1	0	8
Qatar	0	1	5
Saudi Arabia	137	212	324
UAE	21	41	76
<b>Population</b>			
Bahrain	638,193	724807	1261835
Kuwait	1,940,786	2264014	2736732
Oman	2,264,163	2429510	2782435
Qatar	590,957	820986	1758793
Saudi Arabia	20,045,276	24041116	27448086
UAE	3,033,491	4069349	7511690
<b>GDP/capita</b>			
Bahrain	12489	18570	18184
Kuwait	19434	35687	45436
Oman	8774	12720	20790
Qatar	30052	52424	72397
Saudi Arabia	9400	1312	16423
UAE	34395	44384	39624
<b>Avg Years of Schooling</b>			
Bahrain	8	9	10
Kuwait	6	6	6
Oman	7	7.8	8
Qatar	7	7	7
Saudi Arabia	7	8	8
UAE	8	9	9
<b>Education as % GDP</b>			
Kuwait		12.7	
Oman	18.2	24.2	
Saudi Arabia	22.7	19.3	
UAE	22.2		

<b>Internet Users/100 people</b>			
Bahrain	6.2	21.3	55.0
Kuwait	6.7	25.9	61.4
Oman	3.5	6.7	62.0
Qatar	4.9	24.7	81.6
Saudi Arabia	2.2	12.7	41.0
UAE	23.6	40.0	68.0
<b>Literacy % of population over 15</b>			
Bahrain			91.9
Kuwait		93.3	
Qatar			96.3
Saudi Arabia	79.4		86.6
UAE		90.0	

(The World Bank, 2013)

**Table 4.2 b**

	<b>Median Age* (Est. 2012)</b>
Bahrain	31.1
Kuwait	28.6
Oman	24.4
Qatar	32.2
Saudi Arabia	25.7
UAE	30.2

(CIA Fact Book, 2012)

**Table 4.2 c GCC Government Main Oil Companies**

<b>Country</b>	<b>Oil Company</b>	<b>Web Site</b>	<b>USPTO</b>
Bahrain	BAPCO	None	16
Kuwait	Kuwait Oil Company	None	621
Oman	Oman Oil Company (Petroleum Development Oman, alliance with Shell Oil, produces more than 80% of the Sultanate's oil and most of its natural-gas supply)	None	343
Qatar	Qatar Petroleum	None	59
Saudi Arabia	ARAMCO	2011 - 159 total, 208 appl. filed, 31 granted	174
UAE	ADNOC (Abu Dhabi) ENOC (Dubai)	None None	2 10

**Source: USPTO Database and Company web sites**

## **Chapter 5 Research Methods**

## **5.1 Introduction**

This chapter discusses the research methods and the rationale for the context of the investigation. It also provides the framework for the study through a discussion of the econometric model that will be used and the assignment of variables and their data sources that provide quantitative value to the variables. A preliminary analysis is discussed and conclusions are drawn from this analysis.

The investigation takes place within a given context: GCC countries. These countries are resource-rich, have heavily invested in infrastructure, technology, and education to transition to a knowledge-based economy, and are socially and economically influenced by the dictates of Islam. As stated previously, valuable insights may be gained from a case study analysis of these countries. While resource rich and cushioned against economic shock, GCC economies are facing pressures of a growing unemployed youth population and social pressures due to globalization. This is true of other predominately Moslem countries in the region and the GCC can show the way forward in meeting these challenges. Valuable insights may also be gained for small well-funded economies that are attempting to increase their innovative capacity. A better understanding of sociocultural dimensions that support innovative capacity can help these countries focus on developing these societal dimensions through education (See Education under 2.5.2 Knowledge-based Economy Infrastructure). Understanding sociocultural influences will also inform policy and effect how governments invest in their own development, as well as contribute to that of other countries.

## **5.2 Research Philosophy and Methodology**

### ***5.2.1 Philosophy***

Philosophy provides a critical and generally systematic approach to the study of fundamental problems connected with issues of existence, knowledge, values, and reason (Grayling, 1998). Through philosophy a researcher can provide a basis for judging and determine justification for claims. The method to be used in a research study requires a philosophical solution to the fundamental question, 'Why research?' (Kramer and Tyler, 1996; Wacker, 1998). Thus philosophy relates to the core assumptions about how the research is conducted (Easterby-Smith et al., 2008; Holden and Lynch, 2004).

According to Kuhn (1970) and others (Blaikie, 2000) research enquiries can be situated within a

particular paradigm and the paradigm determines the strategy and other aspects of the research. Paradigm's may be considered to be ideal or constructed types and have been derived from the work of many writers (Patton, 1988; Smaling, 1994). Burrell and Morgan (1979) used two dimensions in constructing their paradigm, objectivity/subjectivity and radical change/status quo and offered four paradigms: functionalism (objective/status quo), radical structuralism (objective/radical change), Interpretivist (subjective/status quo), and radical humanism (subjective/radical change). Blaikie (2000) offered the following paradigms: Positivism which uses an inductive approach, Critical Rationalism which uses a deductive approach, Scientific Realism which uses a retroductive approach, and Interpretivism which uses an abductive approach.

### **5.2.2 Methodology**

Sociocultural factors that underpin innovation in a knowledge-based economy can be deduced from characteristics that are revealed in transitioning to such an economy, as well as characteristics associated with innovation and creativity in recognized innovative economies. Therefore, a deductive approach will be used, in which assumptions or hypotheses will be formed concerning the socio-cultural factors that are relevant in the knowledge-based economy. In this approach to the creation of new knowledge, "data are used in the service of deductive reasoning, and theories are invented to account for observations, not derived from them." (Blaikie, 2000: 104). Its ontological and epistemological assumptions are derived from critical rationalism (Popper, 1995, 1972). The research constructs theory and expresses it as an argument and then tests the hypotheses by matching them with data. The ontological assumption is that nature and social life consist of essential uniformities, and it is the aim of science to discover these uniformities. In its epistemological assumption, the deductive stance does not make a distinction between observational and theoretical statements (Blaikie, 2000). The researcher is independent from that being researched (Firestone, 1987; Guba and Lincoln, 1988).

The research focuses as a case study on GCC countries that fit a category: resource-rich developing countries that are investing in a knowledge-based economy. The case study approach endorses a focus on just one or more examples (Blaxter et al., 1996). The strength of the case-study method is that it is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, [and it] addresses a situation in which the boundaries between phenomenon and context are not clearly evident," (Yin, 1993: 59 from Pech). Yin continued that the case study also has the capability to "capture process and outcomes in a causal logic model [and] develop lessons generalizable to the major substantive themes in a field." (Yin, 1993: 75). The generalizability of

case studies has been questioned by social scientists, who have a preference for quantitative methods, but Mitchell comments that validity depends on the cogency of the theoretical reasoning rather than the representativeness of the case (Eckstein quoted in Blaikie, 2000: 225). Case studies may be progressed in a variety of ways. The cases in this investigation are six GCC countries that, while varied in their implementation of developing innovation systems, are one entity, the GCC, in being resource rich, having a common heritage, and facing similar issues in creating a future path.

### **5.2.3 Method**

A deductive approach tests hypotheses by matching them with data (Blaikie, 2000). The widespread use of econometric models that measure economic output in relation to inputs in economic literature (Alesina and Ferrara, 2005; Furman et al., 2002; Furman and Hayes, 2004; Granato et al., 2001) indicates that a quantitative method can be used to demonstrate the significance of socio-cultural factors to economic output. Secondary data is available from international organizations, such as the World Bank, OECD, World Economic Forum, Transparency International, and similar sources. Efforts have been made to select the most reliable sources available, given the reputation of the organization and the previous use of the source in academic studies. Multivariate regression analysis offers techniques that can be used to explore the relationship between one continuous dependent variable and a number of independent variables or predictors. It can also be used to address how well a set of variables is able to predict a particular outcome and whether a particular predictor variable is able to predict an outcome when the effects of other variables are controlled (Pallant, 2001:34).

## **5.3 Sociocultural Variables and Hypotheses**

While literature on NIS and economic theory has not pinpointed sociocultural dimensions that may be significant in national innovative capacity, academic literature from several disciplines have indicated characteristics relevant to innovation and a knowledge-based economy. (Chapter 2 Literature Review, Section 2) Setting the context and deciding on the relevance of previously identified variables is part of empirical research preparation and serves to underpin the theory behind each independent variable and links the present work with contributions from the literature (Pontikakis, 2005). Table 5.1a below lists the sociocultural dimensions and indicates whether their significance will be tested.

**Table 5.1a**

<b>Dimension</b>	<b>Description</b>	<b>Significance Tested – Rationale if no</b>
Openness to outside influences	Required for new technology adoption, new ideas, communication in global economy, creativity.	yes
Openness in communication	Required for sharing and disseminating knowledge and creativity.	yes
Cognitive Diversity	Required for creativity and innovation.	yes
Risk attitude	Required for creativity and entrepreneurial endeavors, spirit of independence and individuality.	yes
Adaptability, flexibility	Required to apply skills to new situations and to adapt to changing work and social environments and an unknown future	yes

**Table 5.1b**

<b>Dimensions</b>	<b>Description</b>	<b>Significance Tested – Rationale if no</b>
Independent spirit	Required for resilience and self-reliance.	No. Measurement issue. Hofstede's rating of individuality discarded because of researcher's intent to use only one Hofstede measurement.
Social capital	Required for networking.	No. Has pros and cons and measurement and definition issues.
Trust	Required for honesty in transactions.	No. Rule of law can take the place in business transactions. Measurement issues.
Non-authoritarian	Required for success in environment where knowledge-as-power transitions to knowledge sharing. Also required for creativity.	No. Measurement issue. Hofstede's rating for power distance discarded because of researcher's intent to use only one Hofstede measurement.

To narrow the number of explanatory variables and to gain better results from the regression analysis, several sociocultural dimensions referred to in knowledge-based economy and innovation literature will not be tested. Table 5.1b indicates the rationale for omitting these variables.

## **5.4 Measuring Sociocultural Variables**

The approach used in this research to determine sociocultural dimensions is guided by Fuhrman et. al. (2002) in their research on national innovative capacity. National innovative capacity is the ability of a country to produce and commercialize a flow of innovative technology over the long term. In Fuhrman's model, national innovative capacity depends on the strength of a nation's common innovation infrastructure, the environment for innovation in a nation's industrial clusters, and the strength of links between these two. Fuhrman and Hayes (2004) used this model to investigate innovative capacity in 23 countries, 1979-1999, and determined that several formerly industrializing countries had achieved innovative capacity equal to or greater than that of countries that were known to be historically innovative. The new innovators-Denmark, Finland, Ireland, and South Korea-were labelled emerging innovators (EI), and the historical innovators-German, Japan, Switzerland, Sweden, and the United State (US)-were labelled leading innovators (LI). This investigation will include the two groups, leading and emerging innovators, in addition to GCC countries, to determine the significance of sociocultural dimensions in their innovative capacity. Given that innovative capacity of leading and emerging innovator countries has already been found to be high, they provide a viable sample on which to determine the significance of sociocultural dimensions.

### **5.4.1 The Model**

The model proposed takes into consideration the Furman framework based on the concept of national innovative capacity (Fuhrman et al., 2002). In Furman's model, national innovative capacity depends on the strength of a nation's common innovation infrastructure, the environment for innovation in a nation's industrial clusters, and the strength of links between these two.

The model in this investigation uses the Cobb-Douglas production function to compute Total Factor Productivity (TFP) that will then be used in the second model to determine the significance of sociocultural dimensions in contribution to economic growth. The Cobb-Douglas functional form of the production function, tested by Cobb and Douglas (1928), is commonly used to represent the relationship of production output to inputs. In the basic production function, quantity of capital and



labour, coupled with TFP that represents how they are used, determine the output. In its simplest form, the model is:

$$Q = b_0 L^{b_1} K^{b_2} A \quad (5.1)$$

Where:

Q = total production

L = labour input

K = capital input

$b_0$  = constant

$b_1$  and  $b_2$  are output elasticities of labour and capital, respectively.

The functional form of the regression model to be used is an empirical question. The log-linear form allows variables to be interpreted as elasticity, is less sensitive to outliers, and consistent with prior research (Furman and Hayes, 2004; Jones, 1998; Furman et. al., 2002). Expressing the production function in an alternative but equivalent form of log-log model gives the following:

$$\ln Q = \ln b_0 + b_1 \ln L + b_2 \ln K + \ln A \quad (5.2)$$

Where:

Q is the dependent variable

L and K are the independent variables

A is the residual or TFP and represents all in the variation in data that is not attributable to labour or capital. (Gujarati and Porter, 2009)

Additionally, oil prices have a significant effect on TFP in the resource rich states of the GCC. Therefore, controlling for oil price shocks in computing GCC TFP is required. Using oil price rather than each country's production is appropriate because all countries' GDP depend on oil price, but several are involved in refining and other downstream activities rather than their own production. Therefore:

$$\ln Q = \ln b_0 + b_1 \ln L + b_2 \ln K + \ln A + b \ln p \quad (5.3)$$

Where:

p is the price of oil for each of the years under investigation and b is a parameter. It will be used when computing TFP for GCC countries only.

Solving (5.2) for  $\ln A$ :

$$\ln A = \ln Q - \ln b_0 - b_1 \ln L - b_2 \ln K \quad (5.4a)$$

Solving 5.3 for  $\ln A$  (for GCC controlling for oil price):

$$\ln A = \ln Q - \ln b_0 - b_1 \ln L - b_2 \ln K - b \ln p \quad (5.4b)$$

Parameters for six GCC countries, five leading innovator (LI), and four emerging innovator (EI) countries, as discovered in Furman and Hayes (2004), will be estimated over an 11-year period, 2000-2010. The model can estimate the annual TFP for each country. Variable definition and data sources are stated in Table 5.2a.

The second model takes into account innovations systems. The production of new ideas is a function of resources dedicated to the research process (Furman et al., 2002; Porter and Stern, 2000), the stock of knowledge on which new knowledge can be built, as indicated by Romer (1996), and other factors. Endogenous growth theory emphasized two important determinants of new idea production: an economy's aggregate level of technological sophistication and the resources dedicated to production of new technology. In innovation systems thinking institutions, which provide the rules of the game are relevant to the production of innovation. Therefore, the researcher has elected to include the major determinants of innovation, resources and knowledge stock, and sociocultural dimensions, which not only affect institutions and other components but also incorporate a country's historical experience and geographic conditioning.

The second model estimates the contributions to TFP and therefore growth:

$$\dot{A} = \delta(F^{SCX1}, F^{SCX2} \dots F^{SCX5}) E^\lambda A^\phi \quad (5.5)$$

where  $\lambda$  and  $\phi$  are parameters associated with R&D expenditure and stock of knowledge.

The estimates depend on cross-sectional and time-series variation. Therefore, a year and country group dummy will be added giving the final log-linear regression model.

Assuming  $\ln \delta$  is a linear function of sociocultural factors, taking logs to both side of (5.5), one gets:

$$\ln \dot{A} = \lambda \ln E + \phi \ln A + \delta_1 F^{SCX1} + \delta_2 F^{SCX2} + \dots + \delta_5 F^{SCX5} + b_c C + b_T T \quad (5.6)$$

where C and T are dummies for country and time, respectively; and  $b_s$  and  $\delta_s$  are parameters.

The parameters for all countries will be estimated using a panel dataset for an 11-year period, 2000-2011. This period follows the era studied by Furman and Hayes (2004), and starts the era in which

GCC countries have stated their intents to develop knowledge-based economies. Given EI and LI countries were found to have increased their innovative capacity, sociocultural dimensions revealed to be relevant in their increased innovative capacity could apply to GCC countries in their development.

### **5.4.2 Data**

Implementation of the model requires that each variable be tied to an observable measure, and quantitative data requires that attempts be made to ensure that data is consistent. Therefore, one source, the World Bank, has been used when possible. Identifying data sources offering the most comprehensive data for sociocultural dimensions for the years, 2000-2010, was complex due to sources consistency requirements. The researcher determined that data for a specific dimension would not allow adequate comparison if the same source was not used for each country, and thus sources were discarded because of lack of data for some economies, usually for GCC countries. Where data was missing for a year, the average of the preceding and following year was computed.

The true rate of technological change is considered to be unobservable, and therefore measuring innovative capacity and variables that may be significant in innovation must rely on proxies (Chorafakis and Pontikakis, 2010). Following is a list of variables and the proxies that will be used and/or computed for each.

### **Cobb-Douglas Production Function Variables**

Refer to Table 5.2a for data sources.

#### **Total Production (Q)**

The analysis requires a country-specific indicator for commercially innovative output. GDP is a common measurement for output in a production function (Furman et al., 2002).

#### **Labour (L)**

The analysis requires a skills-adjusted value to reflect real labour input (Gujarati and Porter, 2009). Because the population employed does not reflect quality of labour, the measurement for labour is a function of the average years of schooling times the number employed, which will indicate a true labour value.

#### **Capital (K)**

A common measurement for capital in the production function is Gross Capital Formation (formerly gross domestic investment), which consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation ([www.worldbank.org](http://www.worldbank.org)).

### Oil Price

Brent crude is viewed as the benchmark crude for international oil prices. Therefore, movements in Brent oil prices are a major driver in the valuation of international oil producers. It is used to price two thirds of the world's internationally traded crude oil supplies (Pan, 2013). Price (from Crude Oil, n.d.) is used as a proxy rather than production because all GCC economies are dependent on oil, as producers or as refiners of neighboring supplies.

**Table 5.2a Cobb-Douglas Variables Data Sources**

Variable	Definition	Source
Q	GDP The sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products, without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources, divided by population.	World Bank ( <a href="http://www.worldbank.org">http://www.worldbank.org</a> )
L	Total employed x Average years of schooling (Total employed = % employed x total population) (Average years of schooling available 2000, 2005, 2010. Missing years computed as averages.)	World Bank ( <a href="http://www.worldbank.org">http://www.worldbank.org</a> )
K	Gross Capital Formation (Outlays on additions to fixed assets plus net changes in inventories.)	World Bank ( <a href="http://www.worldbank.org">http://www.worldbank.org</a> )
p	Oil price based on Brent Crude (Used for GCC countries only. Price used rather than production given GCC countries' dependence directly	<a href="http://equity-analyst.com/">http://equity-analyst.com/</a>

	on price and not necessarily on their own production.)	
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## Stock of Knowledge

Refer to Table 5.2b for data sources.

## Patent Stock, Science & Technology Publications

Patents, although not intended to be used as indicators of technological change, are the most widely available measure of innovative output for a broad selection of countries and are related to inventiveness (Griliches, 1990; Chofarakis and Pontikakis, 2010). Patents are, however, affected by factors other than the rate of invention. These factors include a society's propensity to apply for patents, due in large part to economic conditions and the perception of whether the patent actually protects the invention (IPR regime). Patents are not all equal in value in terms of outcome, monetary or otherwise. There is also a difference in the time lapse between application and grant, due partly to national regulations governing patent grant and to the number of examiners working during a given period (Griliches, 1990). To gain an aggregate figure for each country can be complex in that different organizations use disparate counting systems and may assign a patent to the investor's or the inventor's country of origin or residence. Inventors and investors may also be from different countries, which requires fractional patent counts to avoid double counting (OECD, 2006b). Nevertheless, patents are used in empirical studies to demonstrate inventive activity because they provide the best available gauge across countries over time (Chofarakis and Pontikakis, 2010; Porter and Stern, 2000; Furman et al., 2002; Furman and Hayes, 2004; Varsakelis 2006). Also, Griliches (from Chofarakis and Pontikakis, 2010) justifies using patents, despite the problems mentioned above. Given a sufficiently large count, random fluctuations in quality tend to even out. Chofarakis and Pontikakis (2010), in their search of alternative patent indicators, determined that the OECD and USPTO provided the most appropriate sources of patent count for his work on economical innovation. Because of its extensive coverage of countries, the USPTO Utility Patents database will be used for this research. Utility patents refer to patents for invention and are issued "for the invention of a new and useful process, machine, manufacture, or composition of matter, or a new and useful improvement thereof" (<http://www.uspto.gov>) and are an indication of innovative capacity.

Stock of knowledge is a sum value that reflects the store of innovative thinking at a point in time. In exploring different measure for knowledge stock, GDP per capita, and the sum of patents

from the start of the sample until the year of observation, important differences were determined (Furman et al., 2002). While GDP per capita captures the ability of a country to translate its knowledge stock into a realized state of economic development, patent stock constitutes a more direct measure of the country-specific pool of new-to-the-world technology (Furman et al., 2004). PStk, which is cumulative patents representing the stock of knowledge, computed with a 1 year lag.

The use of patents in this case is not to compare countries but rather to determine relative importance of sociocultural dimensions to output within groups that have similar records in patenting per capita and thus are not at a disadvantage relative to each other.

A second proxy that will be used for stock of knowledge is the number of articles published in science and technology media, a value Furman and Hayes (2004) used as a contributing factor in studying innovative capacity. Patent and science and technology data were available from the USPTO and World Bank Science and technology Indicators respectively.

**Table 5.2b Resources, Knowledge Stock, and Sociocultural Variables Data Sources**

Variable		Description	Source
E R&D Investment	R&D Investment (GERD)	Capital devoted to ideas-producing sector of an economy. While R&D trends are specialized in a particular area, outputs impact a variety of sectors (Rosenberg, 1963)	World Bank
A	Stock of Knowledge:	The stock of knowledge drives future knowledge production.	USPTO database. Included: utility patents (patents for invention)
	PStk	While patents is an imperfect proxy, patenting rates constitute “the only observable manifestation of inventive activity with a well-grounded claim for universality (Evenson, 1984; Dosi et al., 1990; Cockburn and Henderson, 1994; Eaton and Kortum, 1996, 1999; Kortum, 1997)	
	S&T Publications (Science and technology publications)	Includes the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. Figure offers additional proxy (Furman et al., 2002)	
F SCX1 Global	Openness to outside influences	KOF index Has 3 categories: Economic – 36% Social – 37% Political – 26%	Index of Globalization <a href="http://globalization.kof.ethz.ch/">http://globalization.kof.ethz.ch/</a> (as of 05/2013)  Alternatives Considered

		Ranking between 1-100	- Global Innovation Index from INSEAD. Captures elements of the national economy that enable innovative capacity. - IMD World Competitiveness Report  Both Discarded: Data not available for all countries.
Variable		Description	Source
F SCX2 OpnCom	Openness in communication	World Bank Governance Indicators Voice and Accountability captures the extent to which a country's citizens are able to participate in selecting their government, freedom of expression, freedom of association, and freedom media. 1-100	World Bank Governance Indicators - Voice and Accountability Index
F SCX3 CogDiv	Cognitive diversity	Diversity in tertiary graduates/participants, computed by the Shannon Diversity Index as follows: $H = \sum (P_i * \ln P_i)$ H = diversity of species P=proportion of species i  For emerging and leading innovators, subject matter of tertiary graduates constituted eight groups or species . For GCC countries outbound and inbound tertiary students constituted the two groups of species.	World Bank Education Database
F SCX4 RskAtt	Risk attitude	Global Entrepreneurship Monitor (GEM) Offers assessment of the entrepreneurial activity, aspirations and attitudes of individuals within a country. Fear of Failure indicates % of respondents who given an entrepreneurial opportunity would decline out of fear of failure.	GEM Consortium Fear of failure rating in Entrepreneurial Attitude. <a href="http://www.gemsonline.org">http://www.gemsonline.org</a> (as of 05/2013)  Alternatives Considered Attitude rating from same source. Discarded: Sparse data availability.
F SCX5 Adapt	Adaptability, flexibility	Hofstede's uncertainty avoidance expresses the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity. Countries exhibiting strong UAI maintain rigid codes of belief and behaviour and are intolerant of unorthodox behaviour and ideas. A higher score indicates little adaptability.	Hofstede et al., 2010

### Resources Dedicated to R&D

Refer to Table 5.2b for sources.

### R&D Investment, Scientists and Engineers Labour Force

The ideas-producing sector of a country can be measured by the number of full-time-equivalent scientists and engineers or gross expenditures on R&D (GERD) (Furman et al., 2002). While individual R&D and engineering efforts tend to be specialized in particular technical and scientific areas, the outputs of R&D impact a variety of economic sectors via direct application or as a basis for future efforts (Rosenberg, 1963). Thus, the overall supply of innovation-oriented labour and capital are key elements of the common innovation infrastructure. For the countries included in this research, availability is the determining factor in choice of R&D expenditures as the measurement that will be used. An innovation-oriented labour value for all countries was not available. R&D expenditures were computed using World Bank GDP figures and GERD as a % of GDP in current \$US.

### **Sociocultural Dimensions**

Refer to Table 5.2b for data sources.

#### **Openness to Outside Influences (Global)**

Openness to outside influences reflects attitudes towards entities outside national boundaries (Potrafke, 2013). The KOF Index of Globalization (see Table 5.2b) measures the three main dimensions of globalization:

- economic
- social
- political

In addition to three indices measuring these dimensions, the overall index of globalization is calculated and refers to:

- actual economic flows
- economic restrictions
- data on information flows
- data on personal contact
- data on cultural proximity.

Other sources investigated (Table 5.2b) were discarded because of data availability for all countries for all years.

#### **Openness in Communication (OpnCom)**

Voice and Accountability Index from the World Governance Indicators from the World Bank



captures perceptions of the extent to which a country's citizens are able to participate in freedom of expression, freedom of association, and a free media, as well as participation in selecting the government. This measurement reflects openness in communication (O'Neill et. al., 2007).

### **Cognitive Diversity (CogDiv)**

The indicator for cognitive diversity was computed using the Shannon diversity index (H), an index commonly used to characterize species diversity in a community. The index accounts for both abundance and evenness of the species present. The proportion of species (i) relative to the total number of species (p) is calculated, and then multiplied by the natural logarithm of this proportion. The resulting product is summed across species, and multiplied by -1.

In the case of leading and emerging innovator countries, cognitive diversity was computed by determining the index from the number of graduates over eight categories of tertiary graduates available from the World Bank Education database. Tertiary graduates per discipline values were not available for GCC countries. Given the homogeneity of society and religion, the value of graduates studying abroad is an indication of exposure to diverse ideas, cultures, and different ways of thinking. Therefore the Shannon Diversity Index was computed using inbound and outbound tertiary students as two species, data for which was available from the World Bank Education database.

### **Attitude Towards Risk (RskAtt)**

Entrepreneurship can be defined as a dynamic interaction of entrepreneurial attitudes, entrepreneurial activity, and entrepreneurial aspiration that vary across stages of economic development ([www.thegedi.org](http://www.thegedi.org)). The attitude sub-index ([www.gemconsortium.org](http://www.gemconsortium.org)) identifies entrepreneurial attitudes associated with entrepreneurship-related behaviour of a country's population, and measures a society's basic attitudes toward entrepreneurship through education and social stability. Fear of failure, which inhibits entrepreneurship and is inversely proportional to innovative activity, will be used as the measure of risk attitude. While complete data was not available for all years for all GCC countries, Fear of Failure was available for other Arab Fertile Crescent countries, and that data was used as a proxy for GCC countries.

### **Adaptability (Adapt)**

Hofstede (1980) saw uncertainty avoidance as measuring the ability of a society to deal with the inherent ambiguities and complexities of life. Cultures that are high in uncertainty avoidance rely heavily on written rules and regulations, embrace formal structures as a way of coping with

uncertainty, and have little tolerance for ambiguity or change (Hofstede, 1980). Hofstede's value for uncertainty avoidance will be used for adaptability.

## 5.5 Preliminary Analysis

The intent in this research was to compute TFP, or the residual from the Cobb-Douglas production function, model (5.2), to be used as the dependent variable in determining the significance of sociocultural variables in economic output. The Cobb-Douglas was run separately for each country within the three groups, GCC, leading innovators (LI), and emerging innovators (EI). The resulting residual had both negative and positive values, which were transcribed to percentages to avoid computing Ln of a negative number. While the Cobb Douglas model captured at least 90% of the variability in production output for each country, using TFP as the dependent variable in model (5.6) ( $\ln \dot{A} = \lambda \ln E + \phi \ln A + \delta_1 F^{SCX1} + \delta_2 F^{SCX2} + \dots + \delta_5 F^{SCX5} + b_C C + b_T T$ ) revealed issues in using TFP to represent innovation output. Using dummies to represent the respective groups, GCC, emerging innovators, and leading innovators, and a time variable, t, to account for annual change, the model accounted for .035 or 3.5 % of the variability in TFP, and neither the model (sig = .843) nor any of the variables were significant. See Appendix III – Preliminary Analysis for regression results.

In growth accounting measurement (Chapter 2 Theoretical Review), the residual (TFP) reflects technological progress and elements not explained by labour and capital inputs. TFP inherits errors in measurement, new ways of constructing buildings, literacy and skills of the work force and many other factors (Semlali, 1999). TFP is simply too broad and has too much “noise” statistically speaking to be used to represent innovation output, and this was demonstrated in regression analysis

The search began for a new output measure to represent innovation. Determining a measure for innovative capacity is complicated by the fact that it must be comparable across countries over the years being studied. Furman et al. (2002) explored alternative measures to patents, including science and technology publications and TFP and discussed the relative advantages and disadvantages of each measure. While no measure precisely represents innovation in an economy, TFP have already been eliminated. The other two variables, previously discussed under 5.4.2 Data, are possibilities. To represent innovative capacity the measure must indicate commercialisable ideas. While science and technology publications add to the stock of knowledge on which to build

new ideas, they do not necessarily indicate commercialisable ideas. There also are problems in using patents to represent innovative capacity as acknowledged by many authors, including Schmookler, 1996; Pavitt, 1982, 1985, 1988; Griliches, 1984, 1990; and Trajtenberg, 1990. Yet, using international patents as an indicator of innovative capacity is supported by a wide-range of economic and innovation research (Dosi et al., 1990; Eaton and Kortum, 1996, 1999; Evenson, 1984; Patel and Pavitt, 1987, 1989; Soete and Wyatt, 1983). Ultimately, the researcher determined that new patents (NPatent) was suitable as a proxy for innovation because alternatives were less comparable across countries and less closely linked to innovative output (Furman et al., 2002; Chorafakis and Pontikakis, 2010).

The model to be used became

$$\dot{A} = \delta(F^{SCX1}, F^{SCX2} \dots F^{SCX5})E^\lambda A^\phi \quad (5.7)$$

where:

$\dot{A}$  = New to the world flow of innovation or new patents

$E$  = R&D expenditure

$A$  = Stock of knowledge of country j in year t

$F^{SCX}$  = Socio-cultural factor 1-5

$\lambda$  and  $\phi$  are parameters associated with R&D expenditure and stock of knowledge

The estimates depend on cross-sectional and time-series variation. Therefore, a year and country dummy are added, producing the final log-linear regression model.

$$\ln \dot{A} = \lambda \ln E + \phi \ln A + \delta_1 F^{SCX1} + \delta_2 F^{SCX2} + \dots + \delta_5 F^{SCX5} + b_c C + b_T T \quad (5.8)$$

where C and T are dummies for country and time, respectively; and  $b_s$  and  $\delta_s$  are parameters.

This required re-evaluation and re-computing of data that was to be used initially. If new patents was to be used to represent innovation output, the data for all variables would have to take into account the lag between investment and patent grant, which is commonly three years according to Chorafakis and Pontikakis (2010), Furman et al. (2002), and Furman and Hayes (2004). Therefore, data for years 1997-1999 had to be added to existing 2000-2010 data already collected. The results chapter is based on data from 1997-2007, with new patents computed for 2000-2010, the period of focus for this investigation.

## 5.6 Conclusion

This chapter identified sociocultural dimensions that will be tested for their significance in innovative capacity of a country. It discussed a research methodology and provided a model that will be used to test the significance of sociocultural dimensions in innovative capacity in fifteen countries. The sample countries include five leading innovator and four emerging innovator countries, (1979-1999) and six GCC countries. In the preliminary analysis, the researcher found that TFP as output in Model 5.2 had too much *noise* statistically speaking, and an alternative measurement for innovative output was identified as new patents. The following chapter presents the findings based on new patents as a measure of innovative output.

## **Chapter 6 Findings and Analysis**

## 6.1 Introduction

This chapter presents the empirical analysis of data from fifteen economies: five leading innovators (LI), four emerging innovators (EI) (Furman and Hayes, 2004), and six GCC countries. The period being studied 2000-2010 follows the period, 1979-1999, in which Hayes and Stern identified leading and emerging innovators. It is also the era in which GCC countries stated their intent to develop knowledge-based economies. The analysis reveals the results in regressing explanatory variables on innovation outflows using model 4.8 from Chapter 4.

The research has argued that dimensions of a sociocultural nature contribute to innovative capacity. While individuals' characteristics within a national culture differ, the objective here is to pinpoint sociocultural dimensions of the nation and their cumulative effect on innovative capacity.

## 6.2 Data Overview

### 6.2.1 Variable Abbreviations

Table 6.1 lists variables and their corresponding labels that will be used in the chapter.

**Table 6.1 Variables**

Variable	Label
NPatents	New Patents
R&DINV	R&D Investment (Research and Development Investment)
STPubs	S&T Publications (Science and Technology Publications)
PStk	Patent Stock (Cumulative Stock of Patents) with 1 year time lag
CogDiv	Cognitive Diversity
RskAtt	Risk Attitude
OpnCom	Openness in Communication
Global	Openness to Outside Influences
Adapt	Adaptability
LI	Leading Innovators
EI	Emerging Innovators
GCC	Gulf Cooperation Council

### 6.2.2 Descriptive Statistics

A summary of the descriptive statistics of the possible dependent and explanatory variables appears in Table 6.2. The data incorporates information for all groups, GCC, EI, and LI, for the period 1997-2007. New Patents designates new patents for 2000-2010 to account for the 3-year lag between innovative activity and patent output.

**Table 6.2 Data Description**

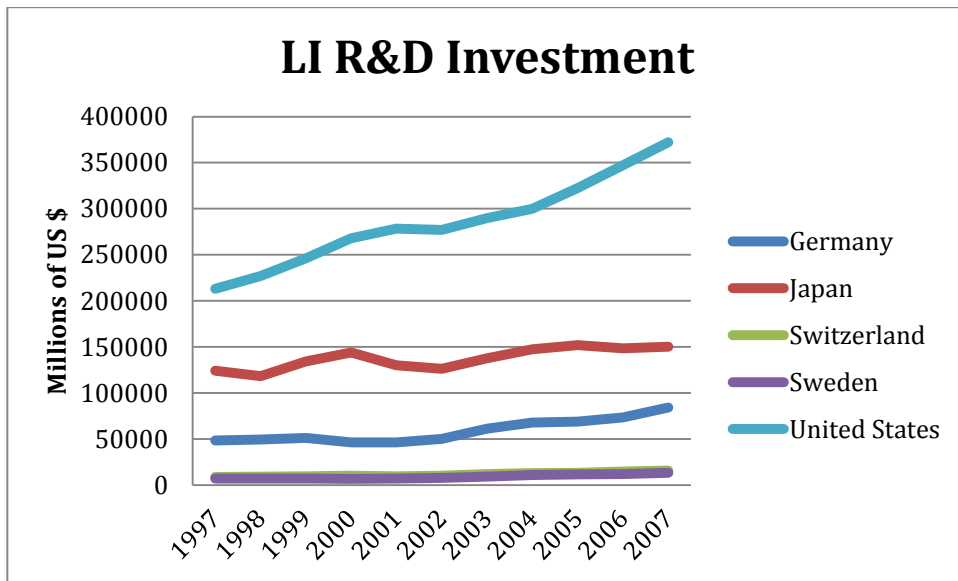
	N	Minimum	Maximum	Mean	Median	Std. Deviation
NPatents	165	0	121179	10439.25	60589.5	25257.22
R&DINV	165	3.277 million	372000 million	354.7 million	186002 million	76849.72 million
STPubs	165	12.8	209898.0	22560.40	104955.4	49459.21
PStk	165	0	1910364	145885.4 5	955182	375314.17
CogDiv	165	.10	2.18	1.22	1.14	.73
RskAtt	165	18	45	30.82	31.5	5.94
OpnCom	165	5	100	64.25	52.5	33.36
Global	165	52.36	91.10	72.39	71.73	12.76
Adapt	165	23	92	64.80	57.5	21.49

### 6.2.3 Trends in Resources and Knowledge Stock

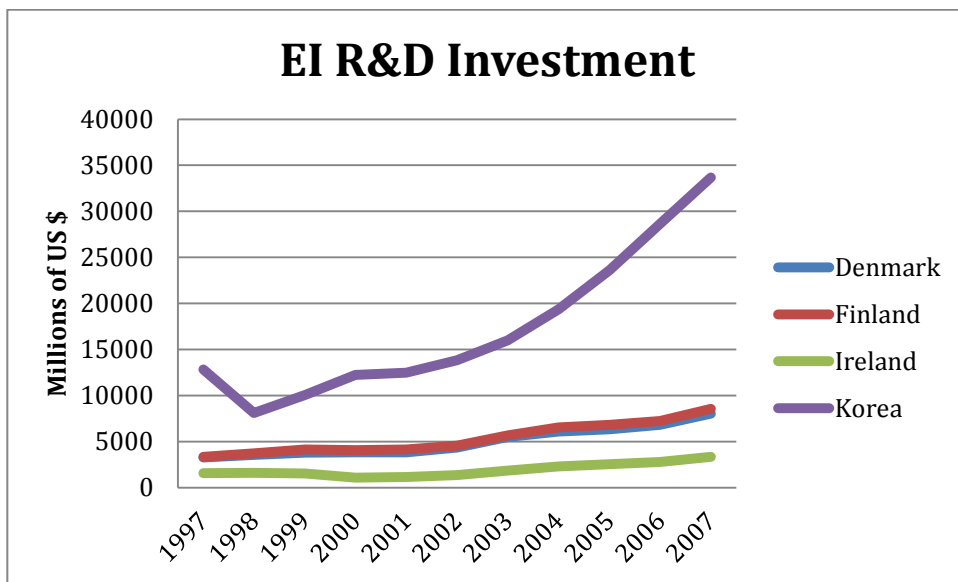
A preliminary examination of two primary inputs in innovation, investment in R&D and stock of knowledge, can provide an overview of how the countries compare in their dedication to innovation. Financial commitments to the R&D process are indicated by R&D Investment, the gross investment in R&D. R&D intensity can be measured by R&D Investment per capita.

During the period 1997-2007, all three groups of countries dedicated increasing amounts of financial resources to the R&D process, as seen in Figures 6.1 a,b,c. Also notice that R&D Investment/capita increased (Figures 6.2 a,b,c). From this data, a commitment to the R&D process seems strong.

**Figure 6.1a LI R&D Investment**

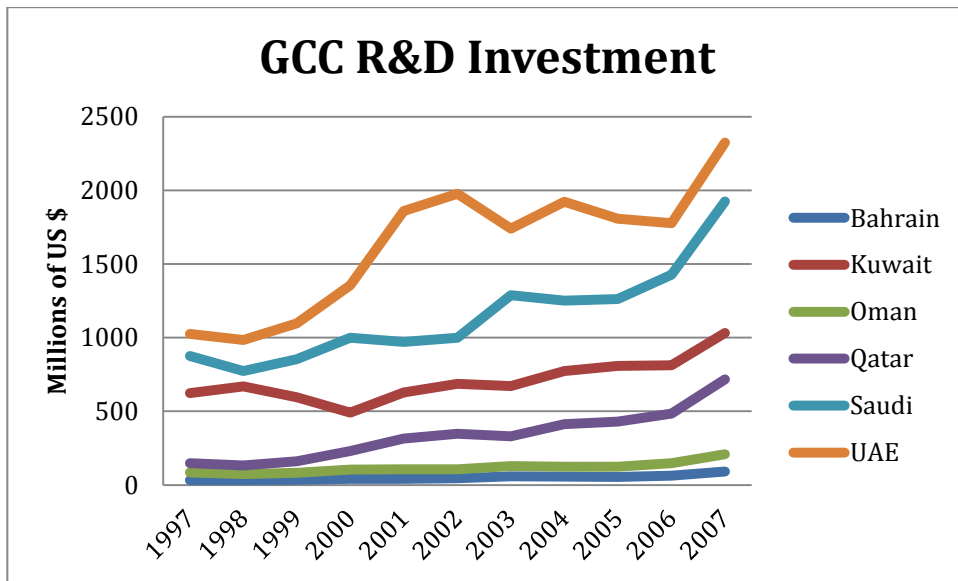


**Figure 6.1b EI R&D Investment**

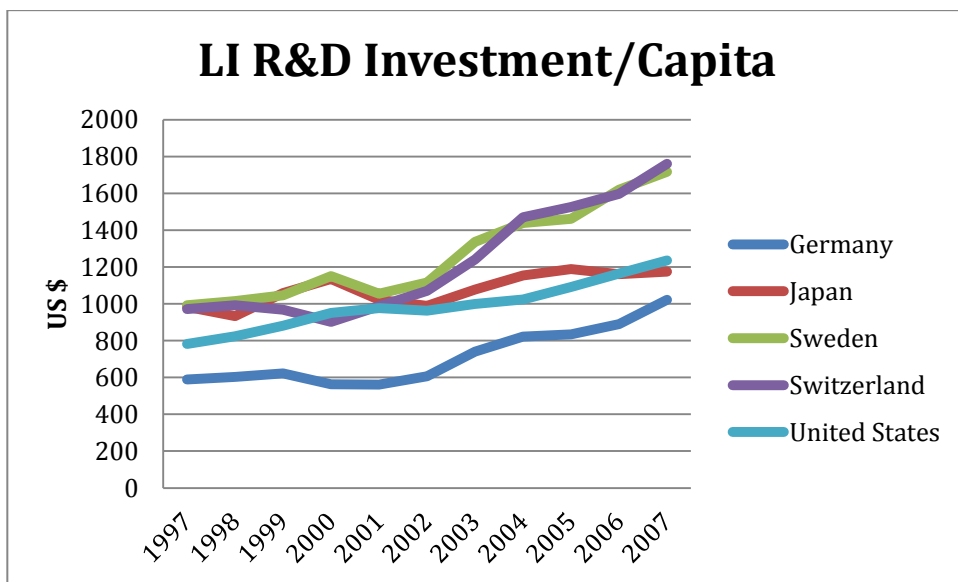




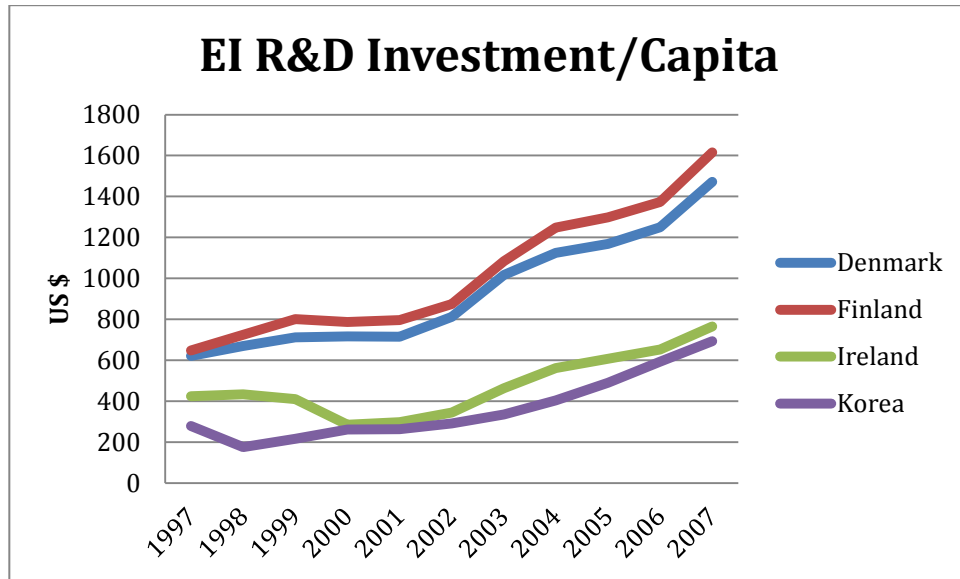
**Figure 6.1c GCC R&D Investment**



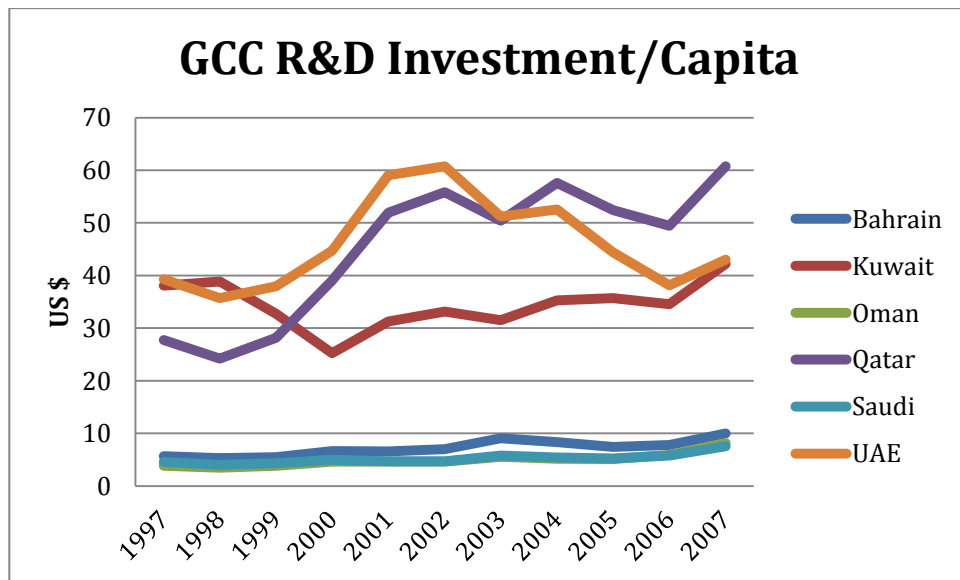
**Figure 6.2 a LI R&D Investment per Capita**



**Figure 6.2b EI R&D Investment per Capita**



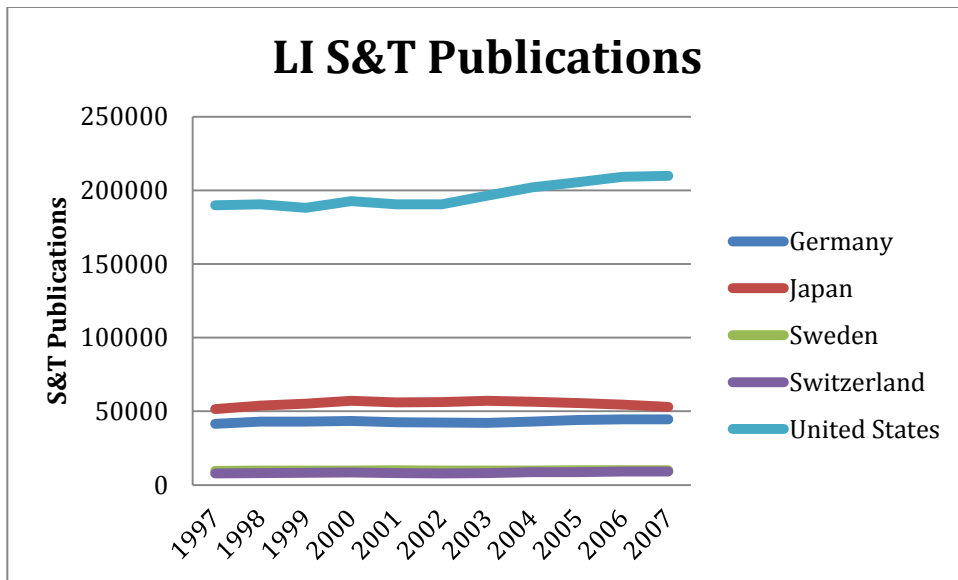
**Figure 6.2c GCC R&D Investment/Capita**



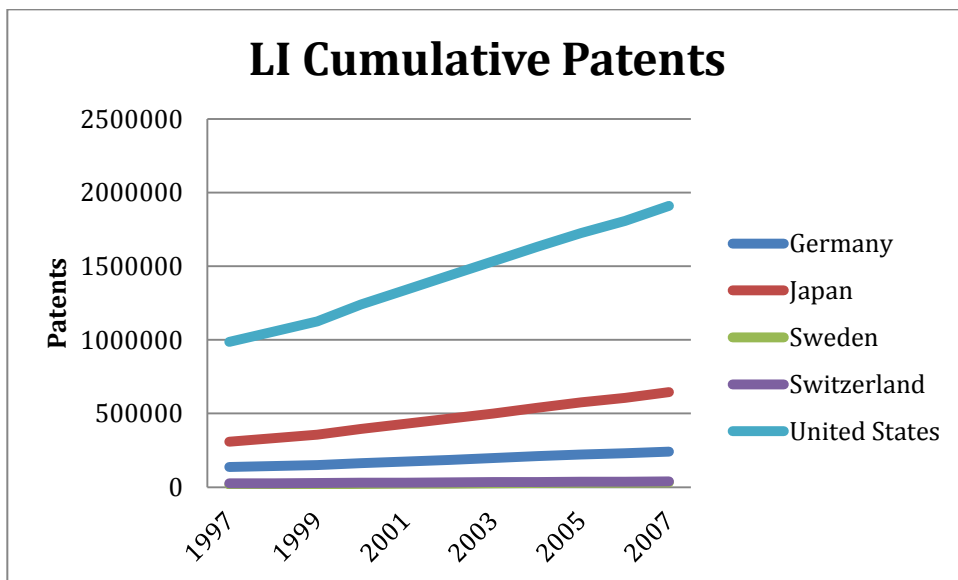
We next examine stock of knowledge, another primary contributor to innovative capacity (Figures 6.3 – 6.5). Among LI countries (Figure 6.3), cumulative patents increased slowly, while the US almost doubled its patent count during the period. This is not surprising given the USPTO is a US system and the US' propensity to patent. Among emerging innovators (Figures 6.4), Korea is noticeable for its significant increase in patents, S&T publications, and patents/capita. Their R&D

Investment/capita did not exhibit the same increase, which leads to the hypothesis that a larger R&D work force and emphasis on building the knowledge stock is part of government strategy.

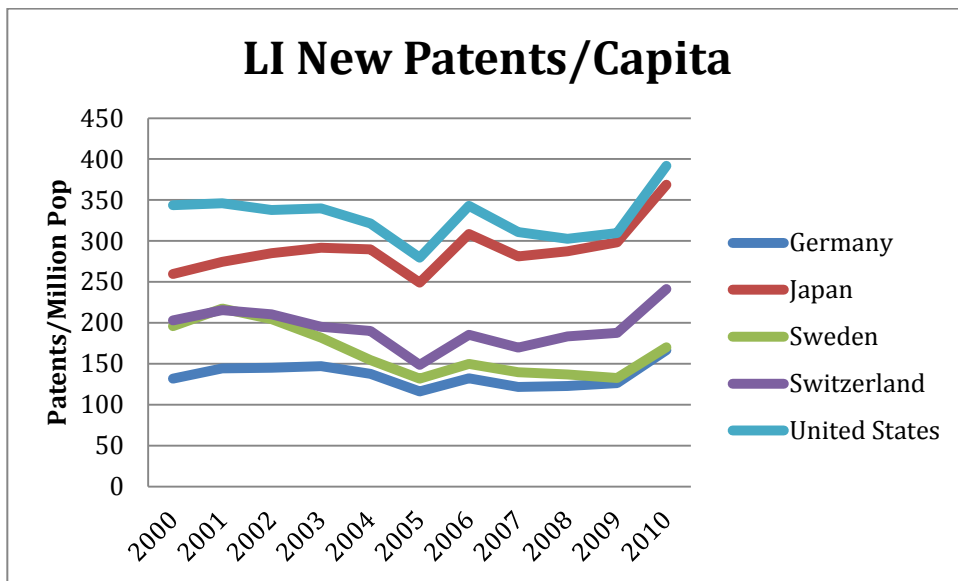
**Figure 6.3a LI Science and Technology Publications**



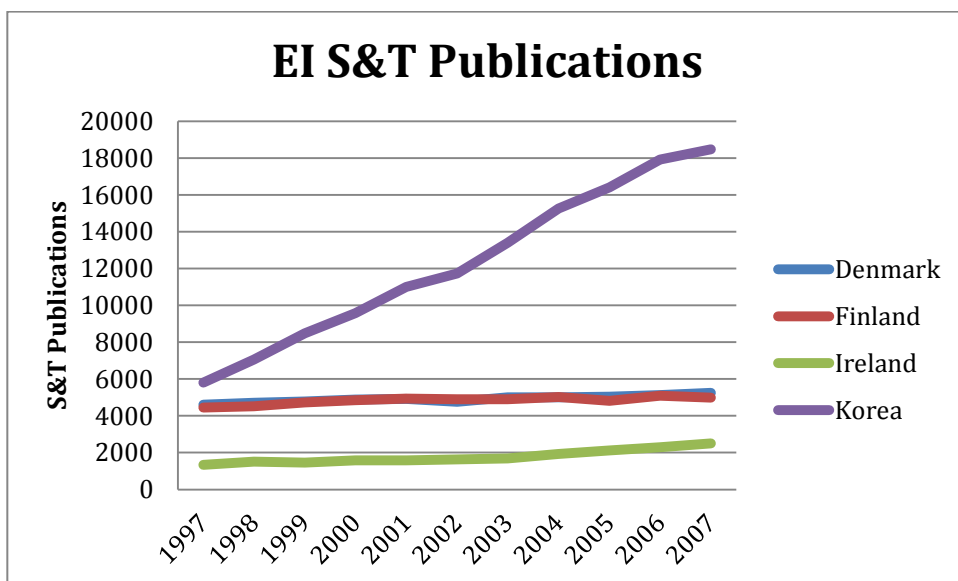
**Figure 6.3b LI Cumulative Patents**



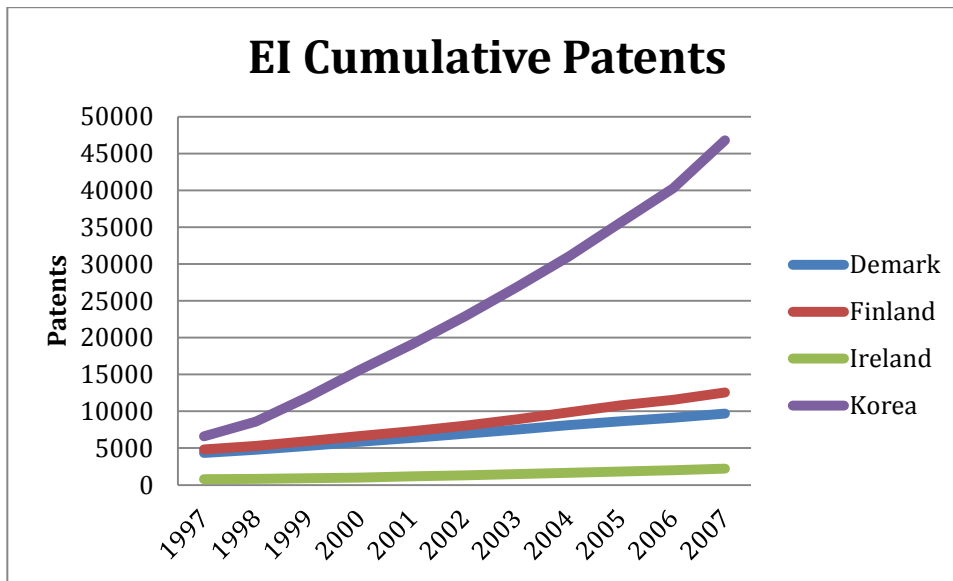
**Figure 6.3c LI New Patents per Capita**



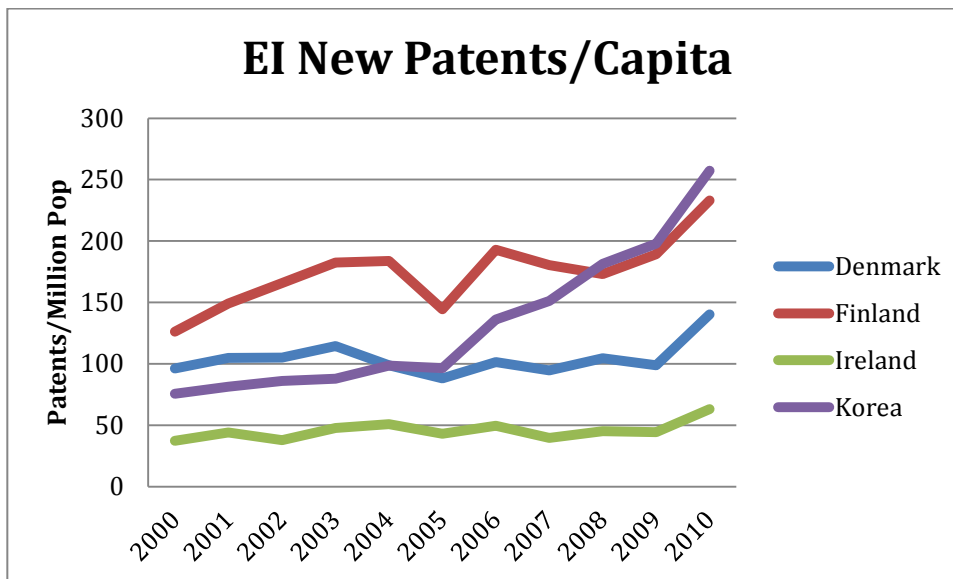
**Figure 6.4a EI Science and Technology Publications**



**Figure 6.4b EI Cumulative Patents**



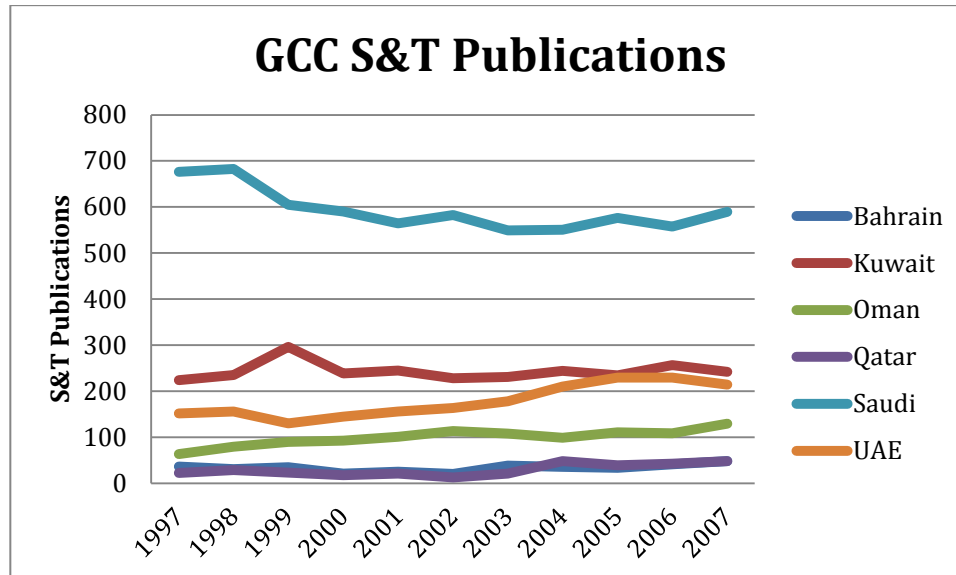
**Figure 6.4c EI New Patents per Capita**



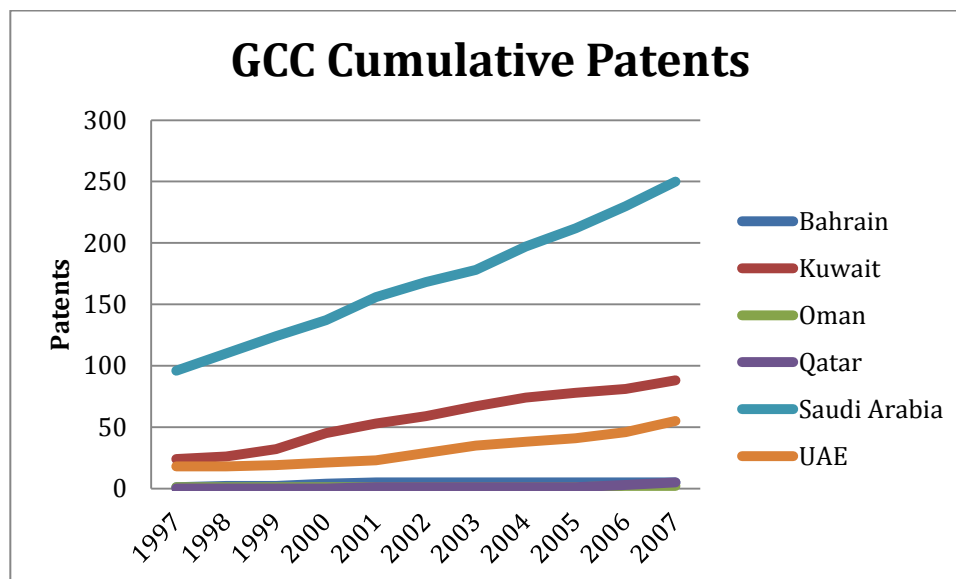
It is noticeable within the GCC (Figure 6.5) that Saudi Arabia continued to build its patent stock, but its S&T publications trend downwards. This may indicate more patenting by Aramco, the Saudi oil company, but little interest in research overall. Further investigation could lead to observations about how to develop the country's motivation to research in other fields. Patent/capita within the GCC is inconsistent. Given that R&D Investment is available, human resources may be limited in

number and skill set (See Chapter 3, Table 3.2 for data on GCC countries). The results indicate that the greater the stock of knowledge the higher the growth percent may be.

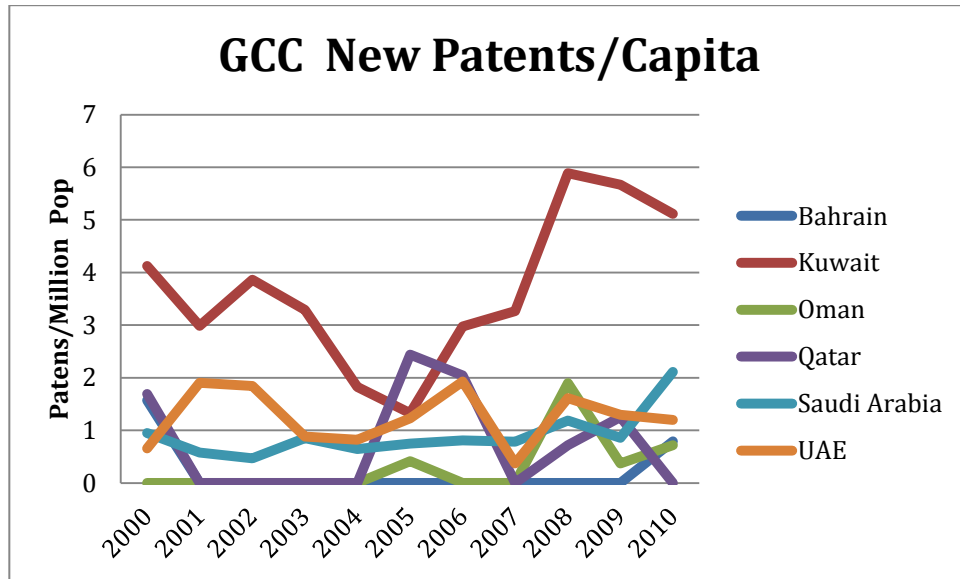
**Figure 6.5a GCC Science and Technology Publications**



**Figure 6.5b Cumulative Patents**



**Figure 6.5c New Patents per Capita**



## 6.4 Quantitative Analysis

### 6.4.1 Correlations

Correlation analysis describes the direction and the strength of the relationships between two variables and can be used to gain further insight into the research questions. The presence of correlation does not necessarily suggest a causal relationship (Devore and Peck, 1993), but it can be used as an exploratory aid.

The Pearson correlation coefficient (*r value*) is a measure of the association between two variables and indicates the strength, direction, and variance of the relationship (Devore and Peck, 1993; Pallant, 2010).

The correlation between each explanatory variable and the dependent variable is desirable in that no relationship would indicate that the sociocultural dimension is not significant in predicting innovation.

Table 6.3 provides Variable Relationships. The initial regression, which includes all variables, indicates that R&D Investment is positively and highly correlated with New Patents at .985 ( $p < .05$ ) and statistically significant at .000 level. The relationship between S&T Publications and New Patents is also highly correlated at .987 ( $p < .05$ ), as are Patent Stock and New Patents. Cognitive Diversity is correlated at .391 ( $p < .05$ ) with New Patents and exhibits the expected sign-the greater

the diversity the more potential for innovative thinking. Risk Attitude has a low correlation at  $-.072$  with New Patents, is not statistically significant ( $.177$ ). Openness in Communication is highly correlated at  $.707$  ( $p < .05$ ) with New Patents and has the expected relationship. Openness to Outside Influences and Adaptability at  $.403$  ( $p < .05$ ) and  $-.316$  ( $p < .05$ ) respectively are correlated with New Patents and indicate the expected relationship.

#### **6.4.2 Multicollinearity**

Multicollinearity refers to the relationship among independent variables and exists when the variables are highly correlated,  $r = .900$  and above (Pallant, 2010). It is an accepted impediment in econometric studies because it is difficult to observe interrelationships in action. Multicollinearity is not necessarily an issue unless accompanied by an inadequate number of observations, in which case it can lead to inaccurate regression models (Gujarati and Porter, 1999). There is disagreement over what the cutoff point for multicollinearity should be (Gujarati and Porter, 1999). Devore and Peck (1993) state that  $r = .800$  and above indicates strong correlation. In the present case, 167 observations without missing data may be sufficient to counteract the problem of multicollinearity. An alternative is to reduce the number of independent variables (Pontikakis, 2005).

In examining values in Table 6.3, we see that multicollinearity exists among Investment in R&D, S&T Publications, and Patent Stock. All are highly correlated ( $r$  above  $.900$ ). While the presence of two collinear variables in a model may not be detrimental, other information must support treating the variables separately. Because these are not the dimensions being investigated, determining which and whether to eliminate one of these variables will depend on regression analysis output in the next section. The cut-off point for discarding a variable should be determined by the theoretical background as well as sample size. There is sufficient evidence that resources devoted to R&D and knowledge stock should be treated as independent variables (Menard, 1995).

Throughout the discussion on culture and sociocultural dimensions, it has been emphasized that cultural factors influence each other and economic outcome. It is therefore expected that there will be correlation among sociocultural variables, and results indicate that fact.

Sociocultural dimensions also affect each other as well as the amount of investment made in R&D, the propensity to apply for patents to protect invention, and the willingness to share knowledge.



**Table 6.3 Variable Relationships**

		NPatents	R&D Investment	STPubs	PStk	CogDiv	RskAtt	OpnCom	Global	Adapt
Pearson Correlation	NPatents									
	R&DINV	.985(.000)								
	STPubs	.987(.000)	.979(.000)							
	PStk	.986(.000)	.981(.000)	.986(.000)						
	CogDiv	.391(.000)	.389(.000)	.349(.000)	.359(.000)					
	RskAtt	.072(.177)	.069 (.188)	.035 (.326)	.049(.268)	.422(.000)				
	OpnCom	.707(.000)	.741(.000)	.688(.000)	.702(.000)	.576(.000)	.134(.000)			
	Global	.403(.000)	.445(.000)	.438(.000)	.488(.000)	.333(.000)	-.023(.000)	.643(.000)		
	Adapt	-.316(.000)	-.357(.000)	-.352(.000)	-.361(.000)	-.454(.000)	.063(.000)	-.555(.000)	-.704(.000)	
	EI	.225(.002)	.225 (.002)	.188 (.008)	.198 (.005)	.976(.000)	.424(.000)	.419(.000)	.255(.000)	-.425(.000)
	LI	.719(.000)	.723(.000)	.735(.000)	.740(.000)	-.250(.001)	-.182(.010)	.512(.000)	.363(.000)	-.180(.010)

## 6.5 Econometric Estimation

### 6.5.1 Regressions

The first regressions tested the significance of R&D (R&D Investment) and stock of knowledge (Patent Stock and S&T Publications) as explanatory variables of dependent variable New Patents for all groups, LI, EI, and GCC. Given their high multicollinearity, the researcher needed to determine how results might be affected by eliminating one of these variables in the final regression to possibly gain improved results.

**Table 6.4 Regressions on Resource and Infrastructure Variables Only -  $\beta$  and Sig Values**

<b>Dependent variable</b>		L(NPatents)	
<b>Independent variables</b>	Resources and 2 knowledge stock variables Model 1 (5.4.1)	Resources and patent stock Model 2 (5.4.2 )	Resources and S&T publications Model 3 (5.4.3)
<b>Resources</b> LR&DINV	.364 (.000)	.478 (.000)	.462 (.000)
<b>Knowledge Stock</b> LSTPubs LPStk	.376 (.000) .258 (.000)	.517 (.000)	.535 (.000)
R <sup>2</sup>	.984	.981	.983
N	165	165	165

The Beta column of the Standardized Coefficient compares the contribution of independent variables. Results (Table 6.4) indicated that R&D Investment, S&T Publications, and Patent Stock explained more than 98% of the variability in the dependent variable New Patent, regardless of which variable(s) are omitted. A regression with R&D Investment, St Pubs, and Patent Stock, including dummy variables for leading (LI) and emerging innovators (EI), and 10 years resulted in a model that explained 98.6% of variation in new patents.

The next step was to determine the contribution of sociocultural variables with the three variations on resources and infrastructure.

**Table 6.5 Regressions on Sociocultural Dimensions and Resource and Infrastructure****Variables -  $\beta$  and Sig Values**

<b>Dependent Variable</b>		L(NPatents)		
<b>Independent Variables</b>	Resources, 2 knowledge stock variables, all SC dimensions Model 1 (6.5.1)	Resources, S&T publications, all SC dimensions Model 2 (6.5.2)	Resources, patent stock, all SC dimensions Model 3 (6.5.3)	Resources, 2 knowledge stock variables, omit Risk attitude, Openness in Communication Model 4 (6.5.4)
<b>Resources</b> LR&DInv	.235 (.000)	.404 (.000)	.339 (.000)	.176 (.000)
<b>Knowledge Stock</b> LSTPubs LPStk	.316 (.000) .388 (.000)	.502 (.000)	.610 (.000)	.328 (.000) .445 (.000)
<b>Sociocultural Dimensions</b> LCogDiv LRskAtt LOpnCom LGlobal LAdapt	.191 (.000) -.013 (.146) -.107 (.009) -.064 (.000) .033 (.009)	.255 (.000) -.017 (.093) -.193 (.000) -.016 (.295) .052 (.000)	.195 (.000) -.016 (.120) -.120 (.008) -.079 (.000) .021 (.127)	.080 (.000)   -.086 (.000) .029 (.018)
<b>Group</b> EI LI	.034 (.262) .026 (.472)	.056 (.098) .061 (.13)	.029 (.402) .024 (.551)	.046 (.113) .037 (.299)
Year Fixed Effects	yes	yes	yes	yes
R <sup>2</sup>	.992	.990	.990	.992
N	165	165	165	165

The model summary for 6.5.1 indicates that the model explains 99.2% of the variance in dependent variable New Patents. The model reaches statistical significance ( $p < .001$ ) and the null hypothesis can be discarded. Risk Attitude is not significant. Sociocultural dimensions Openness in Communication and Openness to Outside Influences are unexpectedly inversely proportional to New Patents, and Adaptability is unexpectedly directly proportional.

The model summary for 6.5.2 indicates that the model explains 99% of the variability in New Patents. The model reaches statistical significance at  $\text{Sig} = .000$  (or  $p < .001$ ), and S&T Publications makes the strongest unique contribution in explaining the dependent variable, when the variance attributed to all other variables is controlled. Also noticeable is that R&D Investment makes a larger contribution to outcome, all other variables being held constant, than in the first regression in which

both S&T Publications and Patent Stock were included. Examining the significance (.093) indicates Risk Attitude is making more of a contribution although not at significance level required for this research. Openness to Outside Influences has now become a non significant variable in its contribution.

The model summary for 6.5.3 indicates that the model explains 99% of the variability in New Patents. The model reaches statistical significance ( $p < .000$ ), and the null hypothesis can be discarded. Patent Stock makes the strongest unique contribution in explaining the dependent variable (.61), when the variance attributed to all other variables is controlled. Also noticeable is that R&D Investment (.339) makes a larger contribution to outcome, although not as large as in the regression that included S&T Publications without Patent Stock. Examining Sig values indicates Risk Attitude, although exhibiting the expected sign, and Adaptability are not making significant contributions. Given that Risk Attitude is not making significant contribution in any of the three regressions, it can be discarded. Openness to Outside Influences has now become a nonsignificant variable in its contribution.

Omitting Risk Attitude, which has not made a significant contribution, provides slightly different results. Each of the dependent variables is significant. Openness to Outside Influences and Openness in Communication maintain an unexpected inverse relationship with New Patents. These unexpected results will be further discussed under Hypotheses Evaluation in this chapter.

$R^2$  provides an estimate of the variance in the dependent variable that is explained by the explanatory variables. It can be noticed in Tables 6.4-6.7 that  $R^2$  is unusually high.  $R^2$  never decreases and usually increases as more independent variables are added, regardless of whether new variables are significant. Also,  $R^2$  can also be unusually high when the dependent variable is trending. In this case, the dependent variable is trending, and dummy variables are used both for country groups and year. In terms of year dummies, 11 variables have been added which significantly increases the number of variables and thus  $R^2$  without necessarily explaining variation in  $y$  (Gujarati and Porter, 2009).

Given the number of explanatory variables and 165 observations, it may be possible to obtain different results with fewer variables. Multicollinearity among resource investment (R&D Investment) and knowledge stock (Patent Stock and S&T Publications) indicates that both

categories of variables may not be necessary. Table 6.6 provides outcome when only one of the three are included in the model.

**Table 6.6 Regressions on Reduced Number of Variables -  $\beta$  and Sig Values**

<b>Dependent Variable</b>		L(NPatents)	
<b>Independent Variables</b>	Model 1 (6.6.1)	Model 2 (6.6.2)	Model 3 (6.6.3)
<b>Resources</b> LR&DInv	.892 (.000)		
<b>Knowledge Stock</b> LSTPubs LPStk		.912 (.000)	.821 (.000)
<b>Sociocultural Dimensions</b> LCogDiv LRskAtt LOpnCom LGlobal LAdapt	-.058 (.093)    .070 (.000)	.071 (.028)    .087 (.000)	.173 (.004)  -.088 (.064) -.047 (.006) .064 (.000)
Group EI LI	.154 (.001) .187 (.001)	.065 (.15) .053 (.330)	.134 (.001) .154 (.001)
Year Fixed Effects	yes	yes	yes
R <sup>2</sup>	.976	.981	.986
N	165	165	165

Patent Stock explains most of the variability in New Patents, which is not surprising. Cognitive Diversity and Adaptability are the only significant sociocultural variables with the expected sign.

Given the intent to determine the significance of sociocultural factors in their contribution to innovative output, a regression analysis of EI and LI countries could provide a clearer picture of the significance of sociocultural dimensions, although fewer observations might affect the regression.

Using R&D Investment as resources and Patent Stock as knowledge base, results reveal several additional insights. Risk Attitude was dropped given that it had not been found to be significant previously. Eliminating Openness in Communication as well indicated that both Openness to Outside Influences and Adaptability were significant at an acceptable level.

**Table 6.7 Regression on Reduced Variables for LI and EI Groups -  $\beta$  and Sig Values**

<b>Dependent Variable</b>	L(NPatents)	
<b>Independent Variables</b>	Model 1 (6.7.1)	Model 2 (6.7.2)
<b>Resources</b> LR&DInv	.505, (.000)	.528, (.000)
<b>Knowledge Stock</b> LPStk	.560, (.000)	.515, (.000)
<b>Sociocultural Dimensions</b> LCogDiv LRskAtt OpnCom LGlobal LAdapt	.113, (.000)  -.147, (.000) .020, (.390) .025, (.122)	.025, (.059)  -.048, (.049) .067, (.000)
Group LI	-.125, (.000)	-.132, (.000)
Year Fixed Effects	yes	yes
R <sup>2</sup>	.992	.99
N	99	99

Given that the objective of the research is to determine significance of sociocultural variables in innovative output in the GCC, running a regression using GCC data only can provide further insight, although the number of observations may be inadequate to obtain viable results. However, as has been discussed, investment R&D and knowledge stock make significant contributions to innovative output. Sociocultural dimensions have been somewhat narrowed-Risk Attitude can be eliminated. We will start with regressions using R&D Investment, S&T Publications and Patent Stock and then add Cognitive Diversity and Openness to Outside Influences. Because all of the GCC countries have the same rating for Adaptability, it would be eliminated by the regression analysis, and therefore will not be included.

As expected R&D Investment, S&T Publications, and Patent Stock make significant contributions. The portion of R&D Investment, around .2 in each case is much less than the contribution R&D Investment made in the sample of fifteen countries. Patent Stock made a larger contribution. Of the

sociocultural variables, Cognitive Diversity was not significant, and Openness to Outside Influences was the only sociocultural dimension found to be significant.

**Table 6.8 Regression on Reduced Variables GCC Group -  $\beta$  and Sig Values**

<b>Dependent Variable</b>		L (NPatents)	
<b>Independent Variables</b>	Model 1 (6.8.1)	Model 2 (6.8.2)	Model 3 (6.8.3)
<b>Resources</b>			
LR&DINV	.178, (.020)	.203, (.016)	.177, .016
<b>Knowledge Stock</b>			
LSTPubs	.295, (.002)	.192, (.049)	.190 (.049)
LPStk	.516, (.000)	.637, (.000)	.666 (.000)
<b>Sociocultural Dimensions</b>			
LCogDiv		.084, (.492)	
LRskAtt			
LOpnCom		-.100, (.459)	
LGlobal		-.152, (.047)	-.171 (.002)
Year			
Fixed Effects		Continuous	Continuous
R <sup>2</sup>	.859	.881	.879
N	66	66	66

### 6.5.2 The Model

The original intent to determine the significance of sociocultural dimensions in innovative output as represented by TFP did not provide significant results. In the search for an alternative approach and measurement, the researcher determined that New Patents provided a suitable indicator of innovative output, and the data was recomputed and additions were made to create a dataset for the years 1997-2007 for all groups, GCC, LI, and EI. This period allowed the researcher to use new patents, including the 3-year lag time, to study innovative output for the year 2000-2010. The model to be used became:

$$\dot{A} = \delta(F^{SCX1}, F^{SCX2} \dots F^{SCX5})E^{\lambda}A^{\phi} \quad (5.7)$$

where:

$\dot{A}$  = New to the world flow of innovation or new patents

$E$  = R&D expenditure

$A$  = Stock of knowledge of country  $j$  in year  $t$

$F^{SCX}$  = Socio-cultural factor 1-5

$\lambda$  and  $\phi$  are parameters associated with R&D expenditure and stock of knowledge

The estimates depend on cross-sectional and time-series variation. Therefore, a year and country dummy are added, producing the final log-linear regression model.

$$\ln \dot{A} = \lambda \ln E + \phi \ln A + \delta_1 F^{SCX1} + \delta_2 F^{SCX2} + \dots + \delta_5 F^{SCX5} + b_c C + b_T T \quad (5.8)$$

where  $C$  and  $T$  are dummies for country and time, respectively; and  $b_s$  and  $\delta_s$  are parameters.

In regressing New Patents on the explanatory variables, it was determined that Risk Attitude was not significant, and omitting Risk Attitude changed, but did not improve, the results. Therefore, regressing all other variables on New Patents gives the following results.

**Table 6.9 Determinants of Innovative Capacity – All Countries (Omit  $F^{SCX}_4$  Risk Attitude)**

<b>Dependent Variable</b> $\dot{A}$	LNPatents	
<b>Independent Variables</b>		Model 4.8
<b>Resources</b> $E_{j,t}$	LR&DINV	.261, (.000)
<b>Knowledge Stock</b> $A_{j,t}$	LSTPubs LPStk	.451 (.000) .332 (.000)
<b>Sociocultural Dimensions</b> $F^{SCX}_1$ $F^{SCX}_2$ $F^{SCX}_3$ $F^{SCX}_5$	LGlobal LOpnCom LCogDiv LAdapt	-1.389 (.000) -.472 (.015) .753 (.000) .252 (.021)
	EI Dummy LI Dummy	.197 (.436) .144 (.619)
$R^2$		.992
$N$		165

Evaluating the resulting statistics starts with the null hypothesis that the independent variables are not satisfactory predictors of the dependent variable, New Patents. The Sig value (SPSS) is less



than 5% for each of the dependent variables, and one can assume that the variables are viable candidates for explaining innovation. It has also been suggested that errors of predication should be minimized, and the models standard error is relatively low at .360.

Goodness of fit, indicating how good the model is at predicting innovation or minimizing predication errors, is demonstrated by the  $R^2$  value, which is .992. This is as expected in that research indicates that investment in R&D and the stock of knowledge heavily affect innovation (Furman et al, 2002; Furman and Hayes, 2004).

Having indicated the validity of the model, individual variables must be examined. According to Gujarati (2009), each variable in a log-linear model measures the change in the dependent variable for each 1% change in the value of a regressor, holding all other regressors constant. A positive sign coefficient indicates a positive relationship with the dependent variable while a negative sign indicates an inverse relationship.

In final analysis, the following model seems to best reveal sociocultural significance in innovative capacity.

$$\ln \dot{A} = .744 + .261 \ln (R\&DINV) + .332 \ln (PStk) + .451 \ln (STPubs) + .753 \ln (CogDiv) - .472 \ln (OpnCom) - 1.389 \ln (Global) + .252 \ln (Adapt)$$

The interpretation is as follows:

If investment in R&D increases by 1%, output will increase by .261%, holding other variables constant.

If the stock of patents increases by 1%, new patent output will increase by .322%.

If Science and Technology publications increase by 1%, output will increase by .451%, holding other variables constant.

If diversity in thinking increases by 1%, output will increase by .753%, holding other variables constant.

If openness in communication increases by 1%, output will decrease by .572%, holding other variables constant.

If openness to outside influences increases by 1%, output will decrease by 1.389%, holding other variables constant.

If risk aversion increases by 1%, output will increase by .252%, holding other variables constant.

The last three observations are surprising in that the explanatory variables are inversely proportional to the outcome and go against innovation system thinking that Openness in Communication and openness to global knowledge and business will increase innovative capacity.

The researcher then sought outcomes from regressing new patents on explanatory variables from leading and emerging innovators, countries that were considered to have increased innovative capacity at the end of the twentieth century. Although the number of observations to support the number of explanatory variables is less than desirable, the regression analysis reveals interesting outcomes. Omitting Risk Attitude and Openness in Communication (which was unexpectedly inversely proportional to output) indicated that Adaptability, Cognitive diversity, and Openness to Outside Influences are significant, although the latter is inversely proportional to output.

**Table 6.10 Determinants of Innovative Capacity – LI and EI Countries (Omit  $F^{SCX}_2$  Openness in Communication,  $F^{SCX}_4$  Risk Attitude)**

<b>Dependent Variable</b> $\hat{A}$	LNPatents	
<b>Independent Variables</b>		Model 4.8
<b>Resources</b> $E_{j,t}$	LR&DINV	.261, (.000)
<b>Knowledge Stock</b> $A_{j,t}$	LSTPubs LPStk	.451 (.000) .332 (.000)
<b>Sociocultural Dimensions</b> $F^{SCX}_1$ $F^{SCX}_3$ $F^{SCX}_5$	LGlobal LCogDiv LAdapt	-.592 (.049) .260 (.059) .303 (.000)
	LI Dummy	-.538 (.000)
$R^2$		.989
N		99

The null hypothesis that the independent variables are not satisfactory predictors of the dependent variable, New Patents, can be discarded given that the Sig value for each explanatory variable,

except Cognitive Diversity, is less than 5%, and the Sig value for Cognitive Diversity is .059, which is acceptable (Gujarati, 2002). The models standard error is relatively low at .229.

Goodness of fit is demonstrated by the  $R^2$  value, which is .989. Again, this is expected in that research indicates that investment in R&D and the stock of knowledge heavily affect innovation (Furman et al, 2002; Furman and Hayes, 2004).

The model becomes:

$$\ln \dot{A} = -10.423 + .674 \ln (R\&DINV) + .475 \ln (PStk) + .260 \ln (CogDiv) - .592 \ln (Global) + .303 \ln (Adapt)$$

The interpretation is as follows:

If investment in R&D increases by 1%, output will increase by .674%, holding other variables constant.

If the stock of patents increases by 1%, new patent output will increase by .475%.

If diversity in thinking increases by 1%, output will increase by .260%, holding other variables constant.

If openness to outside influences increases by 1%, output will decrease by .592%, holding other variables constant (Value expected to increase.)

If Adaptability increases by 1%, output will increase by .303%, holding other variables constant (Value expected to decrease.)

**Table 6.11 Determinants of Innovative Capacity – GCC Countries**

<b>Dependent Variable</b> $\Delta$	LNPatents		
<b>Independent Variables</b>		Model 4.8 Omit $F^{SCX}_4$ Risk Attitude $F^{SCX}_5$ Adaptability	Model 4.8 Omit $F^{SCX}_2$ Openness in Communication $F^{SCX}_3$ Cognitive Diversity $F^{SCX}_5$ Adaptability
<b>Resources</b> $E_{i,t}$	LR&DINV	.190 (.016)	.166 (.015)
<b>Knowledge Stock</b> $A_{j,t}$	LSTPubs LPStk	.206 (.049) .393 (.000)	.209 (.042) .408 (.000)
<b>Sociocultural Dimensions</b> $F^{SCX}_1$ $F^{SCX}_2$ $F^{SCX}_3$ $F^{SCX}_4$	LGlobal LOpnCom LCogDiv LRskAtt	-1.713 (.047) -.204 (.459) .209 (.492)	-1.95 (.002)  1.087 (.174)
$R^2$		.881	.883
N		66	66

Regressing new patents on explanatory variables using GCC data (Table 6.11) revealed more differences in significance of variables. While the number of instances is even smaller than that of leading and emerging innovator countries, it is worth examining the difference. Omitting Risk Attitude and Adaptability, which had the same value for all observations, indicated that Openness to Outside Influences is the only significant sociocultural variable. Cognitive Diversity and Openness in Communication were not significant: (.492) and (.495) respectively. Regressing new patents on R&D Investment, S&T Publications, Patent Stock, Openness to Outside Influences, and Risk Attitude also indicates that Risk Attitude is not significant (.174 ). It can be concluded that Openness to Outside Influences, as measured by the KOF Global Index, is significant for GCC countries.

## 6.6 Hypotheses Evaluation

Multiple regressions were run to verify the significance of variables in their contribution to innovation. The initial regressions were run using all three groups of countries, leading innovators (LI), emerging innovators (EI), and GCC, to determine which explanatory variables representing resources and stock of knowledge were the best fit for the model. Regressing R&D Investment, Patent Stock, and/or S&T Publications on New Patent, resulted in a significant outcome: variables captured from .981 ( $p < .05$ ) to .984 ( $p < .05$ ) of the variability in New Patents (Table 6.4). Next, the significance of sociocultural variables was determined using a panel dataset drawn from all three groups of countries for the years 1997-2007 (2000-2010 for New Patents) (Table 6.5-6.6). Regressions were then run using a panel dataset of LI and EI countries with a reduced number of sociocultural variables (Table 6.5), and a final regression was run of GCC country data only (Table 6.6). A discussion of results follows. Pairs of hypotheses concerning the same sociocultural dimensions are addressed simultaneously.

### **H1: Openness to outside influences increases innovative capacity.**

H1: Supported as significant ( $p < .05$ ).

Openness to new ideas, technologies, knowledge, and processes was expected to directly contribute to innovative capacity, as supported by the literature. A characteristic that was significant to Finland's building a knowledge-based economy and innovation system was the populations' willingness to interact with the outside world in an open way. Dahlman et al (2006) described the Finns as naturally curious about the outside world, which made them open to outside ideas and technology. Negroponte (2003) pointed out in his article on innovation that openness to outside influences encouraged creativity in introducing new perspectives, and knowledge-based economy literature also indicated that technology adoption and exposure to the global knowledge base could allow developing countries to develop at a faster pace (Keller, 2004).

The KOF Global Index was used as the source of data for the variable Openness to Outside Influences. This index measures three dimensions of global engagement: social, political, and economic. In the regression analysis, the  $\beta$  values for Global: -.064 (.000), -.079 (.000), -.086 (.000) (LI, EI, and GCC dataset), were significant but inversely proportional to new patent production (Table 6.5-6.6), meaning that the less global a society, the higher its innovative capacity may be. Global had a high correlation with Cognitive Diversity (.517), which could be considered to partially capture openness to diverse ideas, and a high correlation with Openness in Communication (.643), which captures political freedom in expression. (See below for an analysis of their

respective contributions.) Theory and empirical evidence (Coe and Helpman, 1995; Eaton and Kortum, 1996; Coe et al., 1997) lead us to expect that global connectedness augments the amount of knowledge available. Yet, Furman et al. (2002) found a negative association between their variable for Openness and innovation output but did not discuss the result. Porter and Stern (2000) obtained a negative coefficient to the accumulated patent stock for the rest of the world and interpreted this as a *raising the bar* effect, whereby shifts in the global innovation frontier make it more difficult for an individual country to produce new-to-the-world innovations. Closer integration to the world economy could have a similar effect and should be part of further investigation.

**Table 6.12 Global Index Ratings (out of 100)**

EI	2000	2010	LI	2000	2010
Denmark	89.77	88.1	Germany	81.7	81.52
Finland	87.24	84.34	Japan	58.42	64.12
Ireland	86.75	91.95	Sweden	88.65	88.22
South Korea	58.46	62.38	Switzerland	91.1	86.63
			United States	76.86	74.87
GCC	2000	2010	GCC	2000	2010
Bahrain	66.43	68.83	Saudi Arabia	57.69	62.34
Kuwait	67.47	71.42	UAE	70.74	75.69
Oman	57.54	61.79			
Qatar	53.09	66.52			

Source: KOF Global Index (Rating out of 100)

Leading and emerging innovator countries are globally connected (Table 6.12), and GCC countries increased their scores during the period under study. One may surmise that given the outcome that Openness to Outside Influences is inversely proportion to innovation, another measurement may be more applicable. The KOF Global Index incorporates social, political, and economic categories, and perhaps not all are required for the openness to outside influences for innovation.

## **H2: Openness in communication increases innovative capacity.**

H2: Supported as significant ( $p < .05$ ).

According to the literature openness in communication and a willingness to share information creates links among actors involved in the innovative process, such as scientists, engineers, and others who work for the labs and firms that create new products and processes. The Openness in Communication variable, as measured by Voice and Accountability, was significant but unexpectedly inversely proportional to innovation with a negative  $\beta$  sign:  $-.107$  (.009),  $-.193$  (.000),  $-.120$  (.008) (Table 6.4). Whether regressions included all countries or only LI and EI countries, the

same inverse proportion was indicated. In GCC country data regression, Openness in Communication was not significant.

According to innovation systems literature, the strength of linkages determines the ability of the common innovative infrastructure to lead to innovation in the industrial cluster. Porter's diamond suggests that the strength of the relationship between the common innovation infrastructure and the industrial cluster is an important driver of the overall innovation capacity of a country (Furman et al., 2002). The Triple Helix model suggests that collaborative relationships among the three institutional spheres, universities, government, and industry, contribute significantly to policy and innovation (Etzkowitz and Leydesdorff, 2000). Yet, Negroponte (2003) found that students in the MIT lab were not willing to share ideas until after graduation when they could join the workforce and gain significant value from their work.

The Voice and Accountability Index from the World Governance Indicators (World Bank) captures perceptions of the extent to which a country's citizens are able to participate in freedom of expression, freedom of association, and a free media, as well as participation in selecting the government. The assumption that the political freedom indicated in this measurement is the Openness in Communication required for innovation may be faulty. Given the competitive nature of firms and global business, openness in sharing knowledge for mutual gain requires further research to determine precisely how this openness contributes to innovation. Further investigation might include the ability to form relationships for mutual gain or spontaneous sociability. One may therefore question whether media freedom and having a voice in determining the government's course of action plays the anticipated role in innovative capacity. Rather, an economy that allows actors to reap the benefits of their labour may be the freedom that is most applicable to innovation (Goel and Nelson, 2005).

### **H3: Society's encouragement for taking risks increases innovative capacity.**

H3: Supported as significant ( $p < .10$ ).

A society's attitude towards risk affects its ability to innovate. The U.S.' willingness to take risks and a lack of fear of failure were key ingredients in driving creativity (Negroponte, 2004).

Negroponte found that when failure was stigmatized, economic and social agents were less likely to pursue new ideas and business ventures.

In the regression analysis with all country groups, the  $\beta$  value for Risk Attitude exhibited the

expected sign (-), making Risk attitude inversely proportional to innovative capacity. It explained .017 ( $p < .10$ ) of the variability in innovation in one instance (Table 6.4). In all other regressions, Risk Attitude was insignificant (Sig = .120 and .146).

The Global Entrepreneurship Monitor (GEM) dataset value, the source of the rating for Risk Attitude, indicates the % of respondents that would decline an opportunity due to fear of failure. The dataset is relatively new, 2001, for some countries, and GCC values were not available for all years and countries. They were therefore estimated from an overall average of Arab countries included in the dataset: Egypt, Jordan, Lebanon, Saudi Arabia, Syria, and the United Arab Emirates. Although other data sources were explored, GEM's attitude toward failure seemed the best available. As more data is provided by GCC countries another source may emerge. While entrepreneurship and its role in the Silicon Valley model has been recognized as contributing to innovation, the value being investigated in this research may better match a measure that determines individuality and taking the risk to be different. Societies with emphasis on individuality exhibit a greater tendency to innovate (Shane, 1992; Hofstede, 1984). Hofstede's measure on individuality was not tested because there was no variation in value across the eleven year period and because this researcher was committed to using only one of Hofstede's values. However, it might be noted that Hofstede's value for Uncertainty Avoidance was used for Adaptability. The value was significant but was not inversely proportional to innovation as expected. (See Hypothesis H5.)

#### **H4: Cognitive diversity increases innovative capacity.**

H4: Supported as significant ( $p < .05$ ).

While Dahlman and his fellow researchers (2006) attributed part of Finland's success in developing innovation to the homogenous gene pool, Negroponte (2003) claimed a homogeneous society was unlikely to produce idiosyncratic thinking. Cognitive diversity does not indicate that these two statements contradict each other. Rather, a homogenous gene pool does not mean that cognitive diversity, different ways of thinking and approaching problems, is absent. Page described the cognitive diversity tool box as consisting of:

- Diverse Interpretations: ways of categorizing or partitioning perspectives. This refers to categories people use to classify events, outcomes, and situations.
- Diverse Heuristics: ways of generating solutions to problems. Solutions range in sophistication from simple rules of thumb to sophisticated analytic techniques.
- Diverse Predictive Models: ways of inferring cause and effect. This describes causal



relationships between objects or events. (Page, 2008:7)

Page made a conditional claim that diversity trumped ability in that random collections of intelligent problem solvers could outperform collections of the best individual problem solvers. Cognitive diversity is the result of education and experience, as well as identity, and therefore it is not hereditary like a gene but can be developed through training and engaging in new experiences. Group conflict from identity diversity can be diminished through agreeing on common objectives for outcome from group interaction (Page, 2008).

Cognitive Diversity was significant in all cases, with the exception of regressions run on GCC country data only. The variable explained from .080 to .191 ( $p < .05$ ) (Table 6.4) of the variance in innovation in regressions run using data from all three groups. For GCC countries (Table 6.7), Cognitive Diversity was not significant. The value used to indicate Cognitive Diversity was the diversity in the programs/concentrations of tertiary graduates as computed using the Shannon Diversity Index. In the case of the GCC, given the traditional homogeneity of education in the area and the lack of data for graduates from diverse disciplines, the measure of cognitive diversity was the ratio of outbound students to the total number of tertiary students for each year. As the countries develop their education systems and offer more diverse disciplines and jobs for these disciplines, Cognitive Diversity in the region may make a significant contribution to innovative capacity.

#### **H5: Adaptability to changing circumstances in a society contributes to innovative capacity.**

H5: Supported as significant ( $p < .05$ ).

As the networked global society emerged in a knowledge-based economy, adaptability to a changing work environment (Fukuyama's spontaneous sociability) allowed societies to meet the challenge and pace of change in the way business and life were conducted. This adaptability also translated into an economy's flexibility to adjust to opportunity, as occurred in Finland during the financial crisis of the 1990s. Hofstede (1980) saw uncertainty avoidance as measuring the ability of a society to deal with the inherent ambiguities and complexities of life. Cultures that were high in uncertainty avoidance relied heavily on written rules and regulations, embraced formal structures as a way of coping with uncertainty, and had little tolerance for ambiguity or change. (Hofstede, Mueller & Thomas, 2001).

Adaptability was generally significant ( $p < .05$ ) and explained from .029 (.018) to .052 (.000) of the variability in innovation. However, it exhibited an unexpected sign and was directly proportional to innovation. The rating source used for Adaptability was Hofstede's Risk Averse rating, which states

that the higher the value the less adaptable a country would be. The fact that the value has not changed over time influences the finding.

### **Testing the Model – GCC Countries**

The number of observations for the GCC group was 66, which is not ideal to support the number of explanatory variables. However, results indicated that R&D Investment and S&T Publications and Patent Stock were significant to GCC country innovative capacity. Only one sociocultural dimension, Openness to Outside Influences, was significant and was inversely proportional to innovation. This indicates that openness to outside influences did not increase GCC innovative capacity. As previously stated, theory and empirical evidence (Coe and Helpman, 1995; Eaton and Kortum, 1996; Coe et al., 1997) indicates that international economic connectedness augments the amount of knowledge available. Porter and Stern (2000) interpreted the negative coefficient they obtained in examining the relationship between accumulated patent stock and openness, as resulting from a “raising the bar” effect. Shifts in the global innovation frontier make it more difficult for any individual country to produce new-to-the-world innovations and closer integration to the world economy could have a similar effect. (Chorafakis and Pontikakis, 2011). Therefore, from the results one must conclude that during the period tested none of the sociocultural variables helped to increase GCC countries’ innovative capacity.

### **Summary**

In summary, using a panel dataset that included data from LI, EI, and GCC countries for the period 1997-2010 (input 1997-2007, output 2000-2010) revealed that Cognitive Diversity contributes to innovative capacity. Additionally, Risk Attitude explained .017 of the variability in innovation significant at  $\text{sig} < .1$  for one instance. While other sociocultural variables were significant, the  $\beta$  value sign indicated that the relationship was inversely proportional when the literature suggested otherwise, or directly proportional (Adaptability) when the literature indicated that it should be inversely proportional.

The intent was to determine sociocultural dimensions significant in the dataset for all countries and then test those for GCC countries. The number of observations available for GCC countries for the eleven year period (66) was not ideal to support the number of sociocultural variables in the model, and some were omitted (Table 6.7). Given the unexpected outcomes in inverse relationships, this intent was modified. While R&D Investment, S&T Publications, and Patent Stock were significant, only Openness to Outside Influences was significant for GCC countries and was unexpectedly

inversely proportional to innovation. Therefore, from the results one must conclude that during the period tested none of the sociocultural variables enhanced the development of GCC countries' innovative capacity. Greater insight into the significance of the variables may be gained after GCC innovative capacity has increased significantly over a period of time.

Overall, the model corroborates that Cognitive Diversity, as indicated in the literature, makes a significant contribution to innovative capacity. Risk Attitude was significant with qualifications. In the case of leading Innovator and emerging Innovator countries, both Openness to Outside Influences, and Adaptability were significant but had unexpected signs indicating the higher the openness the lower the innovative capacity and the more adaptable the lower the innovative capacity. Various explanations were offered for the outcomes under the hypotheses interpretations for each sociocultural dimension. Cautiousness is needed when making conclusions based on the null hypothesis: lack of evidence is not in itself proof of functional independence (Pontikakis, 2005: 308). The small number of observations, given the number of explanatory variables, indicates that interpretations should be made carefully.

One possible explanation is that different sociocultural dimensions that contribute to innovation are required at different stages of economic development within an economy. Because innovative capacity has been proven to be affected by the stock of knowledge and the resources devoted to innovation, it is possible that the contribution from sociocultural dimensions may be affected by the level of each of these. In other words, the levels of resources devoted to innovation and the stock of knowledge must be at a certain level before sociocultural values relevant in developed countries will make a difference. The relationship between sociocultural dimensions and the size of the group involved in innovative activities, rather than the percent of work force, needs to be further explored. This value was not available for all countries within the sample and was therefore not included as a resource. Additionally, the sheer number of this group, rather than % of working population, must constitute a significant input into overall innovative capacity. Having a superior level of knowledge stock (S&T publications and Stock of Patents) may affect the type of sociocultural dimension most relevant in contributing to innovative capacity.

An obvious question that results from the findings regards Cognitive Diversity. While significant in regressions on all country groups and leading and emerging innovator countries, it plays an insignificant role in the innovative capacity of GCC countries, which countries are hugely diverse. One explanation may be that power to make decisions and influence outcomes is not equally

distributed among the diverse nationalities and backgrounds. Thus, the gain from diversity is limited by the lack of diversity in power structure and the traditional social capital that inhibits rather than promotes creativity (Florida, 2000 ; Putnam, 1993).

## **6.7 Conclusion**

Chapter 6 analysed the contributions to innovative output by using a panel dataset and log-linear regression model. It was found that the original intent to use TFP as output did not produce a model that was statistically acceptable. An alternative measure, new patents, was identified as a viable dependent variable representing innovative output. Data was described and examined for correlation among variables. Trends in major contributors to innovation, resources and stock of knowledge, were examined to gain insight into differences among country groups. The regression analyses revealed that several sociocultural dimensions were significant in innovation, although Cognitive Diversity was the only one that had the expected sign when using data for all three groups, LI, EI, and GCC. The analysis of the results and recommendations follow in Chapter 6. The results, combined with the literature and information contained in Chapters 2 and 3, provide a basis for examining implications.

## **Chapter 7 Conclusions**

## 7.1 Introduction

The impetus for this research grew out of a desire to impact tertiary education in Dubai, UAE. In the first decade of the 21<sup>st</sup> century, the emirate was in the midst of implementing its strategic plan, with a goal of moving from a natural resource-based economy to a knowledge-based economy, with innovation as a driver. Part of this implementation was the role of universities in developing a competent, entrepreneurial local population. Because the cultural context in which the universities operated differed significantly from the technology industry's innovative culture in which I had previously worked, it became apparent that an investigation of sociocultural dimensions in their role in developing creative thinking was required.

The study is an attempt to define the role of sociocultural dimensions in developing a national innovative environment. National Innovation Systems theory provided a framework through which these sociocultural dimensions could be examined. Sociocultural dimensions were identified through literature on innovation and culture from diverse fields, including economics, sociology, and business innovation. A quantitative approach was used to fill the gap in research on cultural contributions to economic growth through innovation. The outcome has demonstrated that the five sociocultural dimensions are significant in innovation as measured by new patent production. Of greater value is that these same sociocultural dimensions that were significant in innovation in a sample that included leading innovators, emerging innovators and the GCC, were not contributors to innovative capacity in a sample that included GCC countries only. Openness to Outside Influences was significant but unexpectedly inversely proportional to innovative output in the latter sample. The research fulfilled the original intent in highlighting sociocultural characteristics that can be partially developed through the tertiary system.

## 7.2 Limitations

A significant limitation in this study has been the difficulty in defining sociocultural dimensions that should be included. Culture itself has multiple definitions and because of its evolutionary nature, determining how it affects economic behaviour and the innovation that leads to growth is complex. The research attempted to overcome this by canvassing

diverse literature from the social sciences and business to gain multiple perspectives. The list in Table 2.5 was a result of this effort.

Another point to arise from this research was the difficulty in determining sources for quantitative variables that adequately measure national sociocultural dimensions. To conduct quantitative research, not only credible sources are required but also a match between an explanatory variable and a source's description of what it measures must be made. The more precise the match, the more credible is the outcome. While the data sources used were best available in each instance, a more precise match may offer different results.

Data availability was a third issue. As was pointed out in the Arab Knowledge Report 2009, the Arab world lacks a monitor that prepares indices for the Arab region and that guarantees the credibility of data on research, science, and innovation. International institutions suffer from the same shortage of data, such as % of GDP invested in Research and Development.

## **7.3 Implications**

### ***7.3.1 Implications for Theory***

This investigation offers three implications for theory. These include: (1) a re-conceptualisation of National Innovation Systems theory, (2) a revision of the Triple Helix model, and (3) quantitative analysis of cultural factors in economic models.

#### **Re-conceptualize National Innovation Systems**

The first implication for theory is that National Innovation Systems needs to be reconceptualised. This research has determined that five sociocultural dimensions are significant to innovative output, although several had signs opposite to those anticipated. As discussed under hypotheses, this may have been due to imprecise measurement or to requirements that a certain level of economic development be reached or specific sociocultural dimensions must be present for others to be

relevant as anticipated. Nevertheless, while the cultural context has been alluded to in National Innovation Systems literature, it has not been included in the analysis.

Sociocultural dimensions relevant to innovation emerged from an analysis of literature from diverse disciplines, including economics, sociology, and business literature. The study is grounded in multiple perspectives and literature and provides a rich picture of cultural factors that support innovation, not only in their influence on the choice and operations of institutions, but also in their effect on individual creativity within the culture. This highlights a second issue in reconceptualising National Innovation Systems. An emphasis on the individual and creative talent, while indicated in literature on innovation, is missing in the innovation systems approach. Yet, the significance of sociocultural dimensions on innovative output would seem to start with the individual that resides within the culture and is affected by its dimensions. Creativity and the inventor constitute the basic unit in innovation, although not, it seems in innovation systems theory. This basic unit, creativity and inventiveness, is partially developed through the culture in which the inventor resides. The effects of these dimensions on individual inventiveness need to be better explored, not just in business management and sociology literature, but by academics and economists who influence thinking on innovation systems. Cognitive Diversity was found to be significant in innovative capacity, but engineers and scientists involved in R&D are not necessarily a source of the cognitive diversity that may lead to greater creativity. The talent in Florida's (2002) 3 T's (tolerance, technology, and talent) refers to creativity in diverse fields, not just science and technology. If National Innovation Systems is to provide a guide to enhance innovative capacity, then the theory should possibly incorporate a role for individual invention and creativity and the role of sociocultural dimensions in developing these characteristics.

### **Adapt the Triple Helix Model**

A second implication for theory relates to the Triple Helix model. Triple Helix incorporates the aspects of thinking about the roles firms, universities, and government play in producing innovation. Given the significance of sociocultural dimensions in supporting innovation and culture's possible contribution to individual creativity, a model that recognizes this contribution may determine the role of each institution differently. In the Triple Helix model, universities are designated as innovators and creators of knowledge. It is also thought that collaboration among the three entities will lead to government policy more conducive to innovation. Yet, each institution will perform its traditional role, as well as assuming the role of the other two (Etzkowitz and Leydesdorff, 2000). A rethink of the sources of innovation is in order, and the roles of the three



entities must be better defined to produce a supportive sociocultural environment that develops cognitive diversity, a healthy attitude towards risk, and adaptability to changing circumstances.

### **Include the Role of Cultural Variables in Economic Models**

A final implication for theory focuses on the quantitative analysis of cultural influences in economic models. This study, despite the limitations due to the difficulty in measuring cultural factors, in determining data sources, and in obtaining credible data, provides a quantitative analysis that incorporates cultural factors in economic modelling. Previously, it has been thought that culture was too broad and its affects on economic behaviour too vague (Greif, 1994, 2006), to precisely measure culture in an economic model. Although classical economists used cultural explanations for economic phenomena, economists in the latter part of the 20<sup>th</sup> century treated cultural factors as endogenous to the growth model and found no independent role for culture (Coleman, 1990; Lucas, 1976; Stigler and Becker, 1977). This created a problem in methodology (Ingelhart and Baker, 2000; Tabellini, 2008) because determining a cultural effect for economists required identifying an exogenous factor of variation, such as ethnic origin in order to determine effect. Although economic theory has increased in sophistication to incorporate endogenous factors, no need has been felt by economists to introduce additional explanatory variables such as culture (Guiso et al, 2006). Furman and his colleagues (2002) developed a framework based on national innovative capacity. The framework included human capital devoted to R&D, investment in education, and openness to international trade, all of which may be considered outcomes of sociocultural values. This study introduces the possibility of using econometric modelling in addressing cultural issues quantitatively and considerably broadens the scope of what can be determined in pursuing factors relevant to innovation and economic growth.

### ***7.3.2 Implications for Policy - GCC***

#### **The GCC Revisited**

GCC governments and government-owned firms have access to top international consulting firms, such as McKinsey and Company and Booz Allen Hamilton, who have articulated well-developed strategies for their clients. In many cases the governments and firms have adopted the strategies (evidence from consulting company personnel who wish to remain anonymous). Therefore, one should examine obstacles that occur in implementing the strategies rather than in the strategies themselves.

Of the lists of obstacles to implementing strategy, several apply in this context and will be discussed below.

- Inability to overcome resistance to change
- Executing a strategy that conflicts with the existing power structure

The region has an entrenched power structure, as indicated in Chapter 3. Additionally, because Islam is a way of life with every activity regulated by the Koran, it is difficult to alter institutions without the *ulema*, those who interpret the Koran, being in favor of proposed changes. Change becomes high risk and this attitude could have a detrimental affect on innovative capacity. While rhetoric supports innovation, the change that this would involve may be a threat to the existing power structure. A president of a well-respected GCC-based university stated that the greatest obstacle to progress in the education system was the inability to implement change because of pressure from those who opposed change behind the scenes (President and university wish to remain anonymous.). As mentioned in Chapter 3, innovation can be interpreted in two ways, one of which would not be acceptable to conservative Islamists. Additionally, it is a threat to the power base.

- Inadequate information sharing among individuals/business units responsible for executing strategy

Implementation can be complicated by communication. As has been indicated, access to information is power within traditional societies, and changing this structure to one of information sharing to facilitate strategy implementation requires a shift in cultural attitude. Also noted in Chapter 3 was the strong alliance of individuals with their families and tribes. This alignment may form an obstacle to sharing crucial knowledge in a shift to a professional or research-producing setting. Unfortunately, scientific knowledge and aptitude cross tribal and family boundaries.

- Unclear responsibility and accountability for execution decisions and actions
- Lack of ownership of strategy among key employees

Accountability or responsibility often is held by an expatriate who takes the accountability seriously but has little at stake personally in the outcome. All expatriate professionals are under the same basic labour law and can have their labour visa cancelled through a decision of the employing company. This can lead to a lack of feeling of ownership among management and employees key to successful implementation.

In the rhetoric from GCC governments, innovation is a key ingredient to their next steps in development. National Innovation Systems literature suggests a structure to follow, and this research supplements the approach with new findings in the significance of sociocultural dimensions to innovation. Recommendations are made on this basis.

### **Recommendation 1 - Increase Investment in R&D**

From the research it was reconfirmed that investment in R&D is highly significant in innovation, as is the stock of knowledge, which together account for over 90% of the variability in innovation. As a first recommendation, the governments need to invest a % of GDP equivalent to the emerging innovators (Denmark: 3.06%, Finland: .88%; 2010 figures, World Bank) that successfully increased innovative capacity, surpassing more innovative countries during the 1979-1999 time frame. (Furman and Hayes, 2004)

### **Recommendation 2 - Publicize and Share Regional Innovation**

Increasing the stock of knowledge is a part of the strategic plan for the Arab World. Because natural resources and their down line industries provide an initial starting point for further research in the area, innovation within this industry should be conducted and publicized. A scan of each country's oil company web site indicated that innovation and patents were not high profile, with exception of Saudi Aramco. Yet, a search through the USTPO database indicated that patents were owned by GCC oil companies (Table 3.2). A second recommendation is to publicize and make available within the region the innovation that is occurring within their natural resource industry. What starts as an innovation in one situation can transfer to another application, which then starts the trajectory towards increased innovation, as occurred in the Silicon Valley model.

### **Recommendation 3 - Require Innovation Output from Industry Zones**

Dubai has implemented a cluster concept in its establishment of zones focused on diverse industries: technology, financial services, media, and education. These zones consist of separate business entities: Internet City, Media City, Knowledge Village, and DIFC (Aubert et al, 2003). The government's intent was that business entities would engage in innovation at their Dubai sites. Many of the organizations have established marketing and sales units in Dubai, and innovation is conducted elsewhere. Therefore, a third recommendation would be to modify the requirements for a company to establish a presence in an industry zone. Joint patent application, technology sharing, or publication of articles in science and technology periodicals are examples of requirements that could be part of an agreement with a zone firm.

### **Recommendation 4 - Implement Diverse Immigration and Residency Options**

Successful implementation of strategy requires the support of managers/directors in charge of implementation. Yet expatriate labour, including those from Arab countries, is under the same labour law as construction workers. Immigration is open to only a few through the right

connections. Semi-permanent residence status, although offered as part of property purchase in some instances, does not give a professional a stake in the company. Therefore, top professionals, including scientists and engineers, come for financial reward, knowing that long-term commitment and gaining a stake in developing innovative capacity is not possible. A fourth recommendation is to offer options in immigration and residency, value of the professional in developing the firm or organization. Different types of citizenship/residencies are possible.

#### **Recommendation 5 - Establish Scientific Laboratories with Concrete and Measurable Goals**

A modification of the labour law would facilitate the development of the fifth recommendation, which is to establish a center of excellence/scientific lab on which to build a competitive competency. Import the top labour and allow this experienced leadership to create a team of competent individuals with whom the local population can work (not manage) to better understand the field. Qatar has been successful in recruiting respected universities' highest quality programs to Qatar to educate its population. However, employment is short term. The UAE and Qatar have brought in high quality coaches for football and recruited talented players to increase visibility in the sports arena. Will these players and coaches be able to contribute past a certain level?

#### **Recommendation 6 - Develop Cognitive Diversity**

From the research we learned that cognitive diversity is significant in innovative capacity. Cognitive diversity incorporates diverse ways of categorizing perspectives (interpretations), diverse ways of generating solutions (heuristics), and different ways of inferring cause and effect (predicative models). (Page, 2008:7) Page investigated the causes of this diversity and determined that there were two direct causes, training and experiences, and one indirect one, identities. (Discussed in Chapter 2, Literature Review.) The more tools we amass through training, refine by experience, and filter through our identities, the better. A person's ability to contribute improves if he/she can see a problem in multiple ways and if he/she can apply diverse heuristics.

Creating cognitive diversity is the sixth recommendation. Gulf countries enjoy diversity in their labour forces, as well as religious diversity in Islamic sects. However, not all labour, nor sects, have equal power to participate and provide input into the system. Therefore, a first step for GCC countries is to address this imbalance through policies offering the ability to contribute and participate in incentives equally in a professional setting.

To produce cognitive diversity among nationals and expatriates, education as an actor and the

government as education policy maker, can play central roles in setting graduation requirements that include a spectrum of courses from liberal arts and cross-discipline activities. For example, one Dubai initiative offers scholarships to students that select the Arabic tract in pursuing a BA in Communications at the American University in Dubai. Two tracts are available, one concentrating on working with English language media and the other, the Arabic tract, emphasizing working with both Arabic and English media. The scholarship is through the support of Dubai's ruler, Sheikh Mohammed. The scholarship demonstrates his commitment to Arabic and is considered an implementation of the initiative for the transfer and indigenization of knowledge set out in the Arab Knowledge Report 2009.

Cognitive Diversity gained from experience is an issue for GCC nationals. Because of the availability of cheap labour and traditional family hierarchy, learning experiences and making choices in daily life are more limited. The education system can somewhat alleviate this problem through structuring a learning process that requires case studies and through requiring that students participate in an internship prior to university graduation. At the firm level involving locals in key processes, meetings, and experiments, in which there is group participation, at an early stage in the local's employment provides experiential learning opportunities prior to the local attaining significant responsibility in the firm.

#### **7.4 Further Research**

Because of the complexity of defining sociocultural dimensions, the lack of data and the difficulty of determining sources, a qualitative study at the firm level could overcome some these limitations and complement this investigation. An abductive approach that sees innovation unfolding through eyes of the firms would allow the researcher to identify cultural aspects that have aided the innovation process through participants' eyes. They would define the dimensions from their perspectives. This is, in fact, the researcher's next project.

From this study it appears that the UAE has been the most forward thinking of GCC countries in implementing strategy. The project can start with interviewing those involved in the development of business over time in Dubai.

## 7.5 Conclusion

The study of cultural contributions to economic growth has come a long way. Because culture is broad and how it affects economic behaviour is vague, addressing components of culture has provided little hope for economic development for non-developed regions (Guiso et al, 2006) until recently. Although classical economists used cultural explanations for economic phenomena (Smith, 2006), economists in the latter part of the 20<sup>th</sup> century treated cultural factors as endogenous to the growth model and found no independent role for culture. (Stigler and Becker, 1977; Coleman, 1990) This created a problem in methodology (Tabellini, 2008; Inglehart and Baker, 2000) because determining a cultural effect for economists required identifying an exogenous factor of variation, such as ethnic origin, in order to determine effect. Economic theory has increased in sophistication to incorporate endogenous factors, and it seems that additional explanatory variables such as culture can and should be included in economic growth models. Economists' perspectives, methodology, and data availability have evolved to the extent that it has become possible to conduct quantitative research on the contribution of cultural factors to innovation, however rudimentary the study. The present work contributes to the literature by determining that cultural factors are quantitatively significant in enhancing innovative capacity and thus offers implications for theory and policy based on the literature and the findings.

This chapter discussed findings from the research and provided implications for theory and policy based on those findings and the literature. Implications for theory include rethinking National Innovation Systems theory and the Triple Helix model to better incorporate the importance of cultural dimensions in creativity and invention. A third, and clearly significant implication, is the possibility of quantitative analysis of cultural influence in economic models.

The implications for policy targeted the GCC, the focus of this study. The chapter assumed that GCC countries have strategies for increasing innovative capacity and therefore recommendations lay in the realm of implementation of these strategies. The governments are fortunate in having funds to invest in research and development projects that will enhance the innovation process. The recommendations provide an additional avenue along which they may proceed to develop sociocultural dimensions that support strategy implementation. While GCC countries differ in their approach to modernization, similarities are deep enough that collaboration and sharing of outcomes of innovation efforts can greatly enhance innovative capacity for all countries in the Gulf region.

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# Appendices

## Appendix I – GCC Research Organizations

Research Organization	Objective/Mission	Projects/Centres
<b>Bahrain</b>		
Not/applicable		
<b>Kuwait</b>		
Kuwait Foundation for the Advancement of Sciences <a href="http://www.kfas.com">www.kfas.com</a> Founded 1976 Managed and administered by Board of Directors Funding from Kuwaiti Shareholding Companies, amounting to 1% of the net annual profit (List not available.)	Stimulate, support, and invest in initiatives and human resources that contribute to the building of a strong STI system and culture and fostering an enabling environment.	Dedicated to research in Social Sciences and Humanities, Biological Sciences, Medicine Sciences, Natural Sciences, Engineering Sciences and Technology  Centres: <ul style="list-style-type: none"> <li>• Dasman diabetes centre</li> <li>• Sabah Al-Ahmad Centre for Giftedness &amp; Creativity</li> <li>• Scientific Centre.</li> </ul>
Arab Fund for Economic and Social Development (AFESD) 1974 <a href="http://www.arabfund.org">www.arabfund.org</a> members – 15 Arab states and DJIBOUTI MAURITANIA PALESTINE SOMALIA SUDAN	Focused on funding economic and social development by financing public and private investment projects and providing grants and expertise.	<ul style="list-style-type: none"> <li>• Loans to public and private sector projects</li> <li>• Grants - 5% of the profit directed towards grants that provide institutional support to member states.</li> <li>• Scholarships to Arab Ph.D. holders in different fields of specialization.</li> </ul>
Kuwait Fund for Arab Economic Development (KFAED) <a href="http://www.kuwait-fund.org">www.kuwait-fund.org</a> First annual report 1962-1963	Assist Arab and other developing countries in developing their economies through loans, grants for technical projects, and contributions to capital stocks of international and regional development institutions.	Focused primarily on the sectors of: <ul style="list-style-type: none"> <li>• agriculture and irrigation</li> <li>• transport and communications</li> <li>• energy</li> <li>• Industry</li> <li>• Water and sewage.</li> </ul>

Research Organization	Objective/Mission	Projects/Centres
<b>Oman</b>		
Oman Scientific Research Council Ministry of Higher Education <a href="http://www.mohe.gov.om">www.mohe.gov.om</a>	Detailed information not available.	
The International Research Foundation (IRF) Sultanate of Oman <a href="http://www.irfoman.org">www.irfoman.org</a> Under The Research Council	Create an innovation ecology that is responsive to local needs and international trends, fosters social harmony, and leads to creativity and excellence.	<ul style="list-style-type: none"> <li>• Research grants, awards and development program</li> <li>• Innovation assistance programs</li> </ul>
<b>Qatar</b>		
Qatar Foundation <a href="http://www.qf.org.qa">www.qf.org.qa</a> Founded 1995 Qatar Foundation for Education, Science and Community A private, non-profit organization	Core mission areas: education, science and research, and community development. Supports an innovative and open society that aspires to develop sustainable human capacity, social, and economic prosperity for a knowledge-based economy.	<ul style="list-style-type: none"> <li>• Educational institutions in Qatar</li> <li>• Science and research</li> <li>• Community development.</li> </ul>
Qatar National Research Fund <a href="http://www.qnrf.info/s2/index.php">www.qnrf.info/s2/index.php</a> Founded by the Qatar Foundation in 2006	Advance knowledge and education by supporting original, competitively selected research in <ul style="list-style-type: none"> <li>• physical, life, and social sciences</li> <li>• engineering and technology</li> <li>• the arts</li> <li>• humanities.</li> </ul>	QNRf criteria: <ul style="list-style-type: none"> <li>• Research results to improve education and health, spur technological innovation and adoption, conserve vital natural assets, and create IP.</li> </ul>

Research Organization	Objective/Mission	Projects/Centres
<b>Saudi Arabia</b>		
<p>National Research Centre for Giftedness and Creativity (NRCGC)  King Faisal University  <a href="http://www.kfu.edu.sa/en/Centers/CreativityUnit">www.kfu.edu.sa/en/Centers/CreativityUnit</a>  Founded 2009, by royal decree</p>	<p>Offer high quality research, consultation, training opportunities and academic services in the field of gifted and talented education.  Implemented through partnerships and collaboration with renowned national, regional, and international centres on giftedness and creativity.</p>	<p>Design development of programmes on gifted education.</p>
<p>King Abdulaziz City for Science and Technology (KACST), KSA  <a href="http://www.kacst.edu.sa">www.kacst.edu.sa</a>  Government funded  Founded 1977</p>	<ul style="list-style-type: none"> <li>Propose and implement national policy for the development of science and technology programs.</li> <li>Coordinate with government agencies, scientific institutions and research centers in the Kingdom to enhance research.</li> <li>Foster national innovation and technology transfer between research institutes and the industry.</li> <li>Foster international cooperation in science and technology.</li> </ul>	<p>Roadmap 2001-2020</p> <ul style="list-style-type: none"> <li>Water</li> <li>Petrol and gas</li> <li>Petrochemicals</li> <li>Nanotechnologies</li> <li>Advanced materials</li> <li>Electronics, communications, and photonics</li> <li>Biotechnology and genetic engineering</li> <li>Information technology</li> <li>Aerospace and aviation</li> <li>Energy</li> <li>Environment</li> </ul>

Research Organization	Objective/Mission	Projects/Centres
<b>United Arab Emirates</b>		
<p>National Research Foundation  <a href="http://www.nrf.ae">www.nrf.ae</a>  Founded 2008  Provides research leadership in the country by advising the Minister of HESR on all research matters, recommending funding initiatives, and administering research initiatives</p>	<ul style="list-style-type: none"> <li>• Support world-class research activities and create an internationally competitive research environment and innovation system in the UAE.</li> <li>• Promote intellectual property development.</li> <li>• Explore new channels of funding for research</li> <li>• Build and disseminate a database of research conducted within the UAE.</li> </ul>	<p>Four centres (from 18 submitted proposals):</p> <ul style="list-style-type: none"> <li>• Water &amp; the Environment</li> <li>• Genes and Diseases</li> <li>• NanoScience &amp; NanoEngineering</li> <li>• Bilingualism &amp; Bilingual Education</li> </ul>
<p>Mohamed Bin Rashid Al Maktoum Foundation  <a href="http://www.mbrfoundation.ae/english">www.mbrfoundation.ae/english</a>  <a href="http://www.nrf.ae">www.nrf.ae</a></p>	<p>Provide Arabs with opportunities to guide the region towards a knowledge economy through promoting entrepreneurship, research and innovation, enhancing access to quality education and professional development; and supporting the production, acquisition and dissemination of Arab knowledge sources.</p>	<p>I- Knowledge Production  II- Entrepreneurship Development  III- Human Capital Development</p>

Research Organization	Objective/Mission	Projects/Centres
UAE (cont.)		
<p>Emirates Foundation  <a href="http://www.emiratesfoundation.ae">www.emiratesfoundation.ae</a>  Board of Directors – generally members of the royal families from the emirates  Government initiative and funding</p>	<p>Work with the private and public sectors using venture philanthropy to identify and inform about challenges faces UAE youth.</p>	<p>Programs</p> <ul style="list-style-type: none"> <li>• Encourage people to volunteer and mobilize resources in the UAE. Reinforce national emergency relief response</li> <li>• Designs and delivers career development projects to empower young nationals.</li> <li>• Think Science</li> <li>• Financial Literacy</li> <li>• Empowerment of Youth with Disabilities</li> </ul>
<p>The Arab Science and Technology Foundation (ASTF)  <a href="http://www.astf.net">www.astf.net</a>  Independent, non-profit non-governmental organization</p> <p>Founded upon recommendations raised from 375 who attended “Scientific Research Outlook and technology development in the Arab world” symposium, April 2000.</p>	<p>Identify and support scientific research activities, conducted in science and technology in the Arab world.</p>	<ul style="list-style-type: none"> <li>• The international initiative to engage the scientific and technological community in developing Iraq</li> <li>• Water desalination and purification’s techniques in the Arab world.</li> <li>• Scientific research and innovation in technology in the Arab world.</li> <li>• Women initiatives.</li> </ul>

Source: Organization web site as listed



## Appendix II - World Competitiveness Pillars

<b>Basic requirements – Factor-driven Economy</b>
<ul style="list-style-type: none"> <li>• Institutions</li> <li>• Infrastructure</li> <li>• Macro economic environment</li> <li>• Health and primary education</li> </ul>
<b>Efficiency enhancers – Efficiency-driven Economy</b>
<ul style="list-style-type: none"> <li>• Higher education and training</li> <li>• Goods market efficiency</li> <li>• Labor market efficiency</li> <li>• Financial market development</li> <li>• Technological readiness</li> <li>• Market size</li> </ul>
<b>Innovation and sophistication factors – Innovation-driven Economy</b>
<ul style="list-style-type: none"> <li>• Business sophistication</li> <li>• Innovation</li> </ul>

Source: The Arab World Competitiveness Review 2010, World Economic Forum

### Innovation Pillar (Ranking out of 139 countries)

	<b>Innovation capacity</b>	<b>Scientific research institutes quality</b>	<b>R&amp;D Company Spending</b>	<b>R&amp;D university industry collaboration</b>	<b>Gov't procurement-technology products</b>	<b>Scientists and engineers availability</b>	<b>Utility patents per million</b>
Bahrain	67	117	101	88	22	41	90
Kuwait	97	75	102	96	90	57	30
Oman	61	57	51	50	11	87	63
Qatar	45	22	41	27	1	9	48
Saudi Arabia	26	37	24	33	10	34	56
UAE	35	45	28	43	3	20	42

Source: The Arab World Competitiveness Review 2010, World Economic Forum

### Innovation Pillar (Ranking out of 139 countries)

	<b>Innovation capacity</b>	<b>Scientific research institutes quality</b>	<b>R&amp;D Company Spending</b>	<b>R&amp;D university industry collaboration</b>	<b>Gov't procurement-technology products</b>	<b>Scientists and engineers availability</b>	<b>Utility patents per million</b>
Denmark	9	12	7	8	9	19	15
Finland	5	13	5	3	6	1	6

Source: Global Competitiveness Report 2010, World Economic Forum

## Appendix III – Preliminary Analysis

GCC Countries Model  $\ln Q = \ln b_0 + b_1 \ln L + b_2 \ln K + \ln A + b \ln p$

Dependent Variable	Ln Q	GDP					
Country		Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE
Oil Price	Ln p	.397 (.000)	.625 (.000)	-.015 (.928)	.312 (.000)	.589 (.000)	.506 (.000)
Labour	Ln L	.336 (.000)	.082 (.149)	.494 (.009)	.430 (.000)	.178 (.011)	.428 (.000)
Capital	Ln K	.307 (.000)	.307 (.006)	.541 (.002)	.279 (.001)	.258 (.007)	.094 (.103)
R <sup>2</sup>		.998	.998	.988	.999	.998	.997
Adjusted R <sup>2</sup>		.997	.997	.982	.999	.997	.996
N		11	11	11	11	11	11

Other Groups Model  $\ln Q = \ln b_0 + b_1 \ln L + b_2 \ln K + \ln A$

EI Countries

Dependent Variable	Ln Q	GDP			
Country		Denmark	Finland	Ireland	Korea
Labour	Ln L	.468 (.053)	.915 (.000)	.301 (.021)	.935 (.021)
Capital	Ln K	.524 (.034)	.086 (.444)	.756 (.000)	.063 (.547)
R <sup>2</sup>		.927	.951	.946	.975
Adjusted R <sup>2</sup>		.909	.938	.933	.969
N					

## LI Countries

Dependent Variable	L Q	GDP				
Country		Germany	Japan	Sweden	Switzerland	United States
Labour	L L	.366 (.002)	.361 (.182)	.165 (.195)	.211 (.072)	.871 (.000)
Capital	L K	.658 (.002)	.570 (.050)	.841 (.000)	.806 (.000)	.207 (.030)
R <sup>2</sup>		.933	.529	.966	.972	.961
Adjusted R <sup>2</sup>		.916	.412	.958	.966	.951
N		11	11	11	11	11

$$\text{Model } \ln \dot{A} = \lambda \ln E + \phi \ln A + \delta_1 F^{SCX1} + \delta_2 F^{SCX2} + \dots + \delta_5 F^{SCX5} + b_c C + b_T T$$

Dependent Variable		TFP					
<b>Resources</b> E	LR&DINV	1.729 (.660)					
<b>Knowledge Stock</b> A	L PStk L S&TPubs	.627 (.897) -.462 (.897)					
<b>Sociocultural Dimensions</b> F SCX1 F SCX2 F SCX3 F SCX4 F SCX5	LGlobal LOpnCom LCogDiv LRskAtt Adapt	.200 (.180) .058 (.879) -.008 (.987) .046 (.607) -.122 (.343)					
	EI Dummy	-.573 (.131)					
	LI Dummy	-.534 (.224)					
R <sup>2</sup>	.203 (.000)						
Adjusted R <sup>2</sup>	.146						
N	165						